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Macroeconomic volatility effect on labour market performance

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Abstract

Macroeconomic volatility effect on labour market performance has been detected for OECD countries during the years of 1985-2011. Current research adds a number of improvements to the subject field. Labour market performance incorporates a large number of associative indicators rather than simple unemployment rate. Variety of performance indicators has been used in attempt to underpin the system mechanism. Advanced techniques are used for volatility estimation. Distinct volatility measures are used for exchange rate, inflation and interest rate series according to their stochastic properties. For long memory inflation series ARFIMA-GARCH models have been used, for interest rates that bare asymmetry due to Central Bank and market interventions QARCH, GJR-GARCH and PARCH models have been fitted. Exchange rate series have been modelled using ARIMA-GARCH and EGARCH. In estimation of volatility effect on labour market performance either random or fixed effects models have been used. Standard errors of the models have been tested and corrected for serial correlation, heteroskedasticity and cross-sectional dependence. For the robustness of the results panel time series methods have been used where possible due to its advantages for macroeconomics models (Eberhardt (2012)). Where use of these methods has been restricted by the nature of the models, Arellano-Bond (1991) and Bruno (2005) models have been fit. Hybrid (Allison (2009)) and Correlated Random effects models (Mundalak (1978) have been used where categorical variables have been included in the regression.

Chapter 1. Introduction

The focus of the thesis is to study the effect of macroeconomic volatilities on labour market performance. However, due to the vague nature of the volatility concept, measuring macroeconomic volatility has been confined to a secondary role in this work. So the answer to the question that has been flagged by this study really consists of two steps. Before moving on to the main question in step two, the question on how to measure macroeconomic volatility has to be answered.

Macroeconomic volatility, and its effect on economic aspects such as trade, investment, and growth, has always puzzled researchers. Evidence of that can be seen from the number of studies that has been attributed to this particular area of research. Every study is unique. However, one distinctive characteristic divides all the previous literature into two groups. This is tightly associated with the names of Robert F. Engle and Tim Bollerslev and their invention of parametric volatility models (Engle (1982), Bollerslev (1986)). The new edition of “Econometrica” Journal in 1982 has given second breath to the academic discussion and truly revolutionised it. Not only historic volatilities could now have been estimated but also using the new type of models gave an opportunity to calculate implied volatilities. The model initially created by Engle (1982) and generalised by Bollerslev (1986) quickly found its applications and extensions. Bollerslev’s “Glossary to ARCH (GARCH)” chapter in “Essays in honour of Robert F. Engle” is the best evidence of that (Bollerslev (2010)). A dozens or more model variations are described there.

It is no surprise with such wealth of new generation of volatility models that this area of research has attracted lots of interest. However, despite such richness in alternative areas of research, it was felt that labour market economics has definitely been missing out on the innovations. A preliminary literature review of macroeconomic volatility effects on labour market performance (Chapter 2 of this research) has returned with modest results. The exchange rate volatility effect on unemployment has appeared to be the most popular topic out of three. GARCH (1,1) and GARCH-M models have been used there. In case of inflation volatility, no parametric models of volatility have been previously used. The theme of interest rate volatility effect on labour market performance has still not been developed and no previous studies concerned with it have been found. Being in labour market research group with special interest in econometrics felt like this is the gap in literature that has to be filled.

The analysis covers twenty OECD economies during the period of 1985-2010. This period of time has been rich in historical events for the countries considered here. They are Austria, Australia, Belgium, Canada, Switzerland, Denmark, Germany, Spain, Finland, France, Italy, Ireland, Japan, Netherlands, New Zealand, Norway, Portugal, Sweden, United Kingdom and the United States.

In 1985 most OECD economies started to recover after the 1980s recession caused by oil price shocks of the 70s. The period of time that is central to this study is characterised by the decline in unionisation. Let’s recall for instance the case of the UK. In 1979 Margaret Thatcher has lead the government as a Prime Minister. During her rule many unions have lost their power, as a result of her policies. Even though UK government’s war against unions’ extensive powers has been an extreme example in history, gradual unpopularity of unions became a trend in other countries too.

Not only were there changes at the country levels, but also the political economy has evolved during this period of time and geographical borders within Europe have changed. In 1989 the Berlin wall was destroyed, and later, in 1990, a new country has been created on the European map – a Unified Germany. The following year, in 1991 Soviet Union has fallen and subsequently 15 smaller independent republics have been created. Contrary to disintegration to the East of Europe, European Union ties became stronger with the fall of communism. Over the 25 years, since 1985 it has expanded from 10 member countries to 28. Closer integration of the countries has been reflected in common law framework introduced to make a single market, customs union, free movement, and monetary union.

In 1985 most of European countries still were part of the European Exchange Rate Mechanism (ERM), which has been introduced in 1979. The concept behind ERM lies in fixed values of European currencies against European Currency Unit (ECU) with the allowance for small fluctuations within established corridors. The corridors were 2.25% for all countries’ currencies except for Portugal, Spain, Italy and the United Kingdom. These countries had a right to exercise larger currency revaluations of 6%. Even though nominally peg values were against the ECU, practically values of ECU were close to the German Deutsche Mark. This has been a result of forming the ECU based on the bilateral trade weights between countries. Not all countries joined the ERM simultaneously. For example, UK was the last to enter the monetary union in 1990 and left it shortly in 1992. European Central Bank has been established in 1998. Common currency – the euro has been introduced in 1998, however banknotes and coins went into circulation only in 2002. So technically, Eurozone has superseded ERM system in 1999. However it still does not include all of its 28 member countries but is limited to only 19.

Rise of the technology era has left its imprint on financial markets not less than political events. In 1980s computerisation has reached stock traders and their operations have been done using program trading. Program trading later has been blamed for Black Monday of 1987. The consequent fall of share prices and indices values has been observed from Hong Kong to Europe and USA without bypassing Australia and New Zealand.

This has been not the only shock to global financial system in the period of 1985 -2010. The incidences of financial shocks (bank insolvency crisis and currency crises, speculative bubbles) started to happen locally in different world regions. But they still were quite isolated and limited to one geographical region. For example, Japan's bubble of 1990 when Nikkei index lost almost half its value in a year, Scandinavian bank crisis of 1992. Increased economic and financial integrity with time made the consequences more severe to world economies as they were falling like dominoes. So the need for regulation has arisen. As a consequence, Basel Committee has been created which produces suggestions for banks capital formation. Despite the advisory nature of these suggestions in some countries, for example G-10, they have been implemented into National Banks' regulating systems. Organisations, such as G-10 and G-20, became much more frequently used to solve the global financial issues. This has been especially obvious in the aftermath of the global financial crisis of 2007. It has affected all of the economies that this study is concerned with and far beyond them. Crisis of 2007 has stemmed up from mortgage lending that has been based on misjudgement and violations of prudency concepts. As a consequence many banking institutions in the financial system experienced solvency problems. This has brought the new wave of recession but this time it has been truly global.

All of the historical events previously listed have to be accounted for in the regression analysis so the outliers produced by these incidents will not distort the results. If ignored, the effect of described events will be partially included in volatility coefficients. In solution to that, regressions will be tested for time effects.

The macroeconomic variables, for which volatilities will be considered here, are the exchange rate, inflation and interest rate. From the variables' observations plots in

Appendix A1, volatility patterns may be observed. What immediately emerges is the interest rates series composition. After 1990s, series became a much better behaved where volatility remains but to a notably lesser extent. This could be a consequence of Central Bank's trend of interest rates control. Similarly, other individual characteristics of macroeconomic variables have to be accounted for when modelling volatility of the series. For example, persistence of inflation series, asymmetric response to shocks in exchange rates (Bailie et. al. (1996), Gray (1996)). All of the historical events during 1985-2010 mentioned earlier can have impact on volatility measures as well. If not controlled, misleading results will be produced by unit root tests. So in order to account for them Andrew-Zivott tests will be performed where needed.

Advanced volatility models are not the only novelty that this thesis brings into the research field, as there are other dimensions to consider. Previous studies have been concerned with typical labour market indicators such as employment or unemployment series. Here additional variables to consider include activity rates, structural unemployment, duration of unemployment and the number of discouraged workers. All of these complementary considerations bring clarity into the mechanics of the effect.

This thesis consists of seven chapters. As has been noted previously, the literature review on the direct link between macroeconomic volatility and labour market performance is very modest. However, Chapter 2 tries to gather as much of the relevant research as possible, including direct and indirect links (e.g. trade), looks at the question from a microeconomics perspective of firm organisation. Then a labour market model is built based on Nickel (1998) and Bassanini and Duval (2006 a and b). Chapter 3 describes in detail dataset construction and its sources. Core chapters to the research are chapters 4 to 6 that are subdivided into two sections of volatility derivations and empirical findings on the macroeconomic volatility effect on labour market performance. Chapter 7 briefly summarises findings of the thesis and lists their limitations together with some further research suggestions.

Chapter 2. Literature Review

There is a lack of literature on the direct link between macroeconomic volatilities and labour market performance. This might have been expected, as one is a macroeconomics phenomenon whereas the other is a microeconomics attribute. It makes it hard to tie in the two concepts in one framework setting. Departing from microeconomics fundamentals in the next section we consider how volatilities indirectly affect firm behaviour under uncertainties that they create. In the following sections, we explore how exchange rate volatility is indirectly connected with labour market performance through the trade, investment and job creation links. In the last section we will review all recent empirical findings on macroeconomic volatility effect and labour market performance.

2.1. Indirect links between macroeconomic volatilities and labour market performance.

2.1.1 Theoretical foundations

2.1.1.1 Firm's behaviour under price and demand uncertainty

Macroeconomic volatility affects the economy at a firm and industry level by introducing uncertainty into its optimisation objectives. Papaioannou (2006), based on Shapiro (1996) and Madura (1989), summarises three types of exchange rate risk that firm's are facing-transaction, translation and economic risks. All of these risk components are as well applicable to interest rates and inflation risks for entrepreneurs. Transaction risk is associated with the liquidity of a firm. Tight contractual obligations to cover receivables, payables and dividends pay out in line with contractual agreements makes firms more sensitive to macroeconomic volatilities and the risk that they carry. Translation risk is a balance sheet risk, i.e. consolidation of current domestic and foreign assets and liabilities on the balance sheet and its misalignment values due to associated variables' volatilities. Economic risk is related to the value of a firm's operating cash flows. Future cash flows can change on a regular basis because of uncertainty effects on production inputs and outputs. Macroeconomic volatility brings in uncertainty into price and demand functions, thus, alters the optimal equilibrium conditions.

Using a static one-period model of a firm's behaviour, whose objective is profit maximisation and risk attitude is described by Neumann-Morgenstern utility function, one derives optimal first and second order conditions in a search for the optimality. The difference in the uncertainty case assumed to be that firm has to make optimal output, price or sometimes both decisions 'ex ante' - based on expectations of price level or demand function rather than on the actual known values of them. The effect of uncertainty on output determination, pricing strategy, and demand for factors of production, increase fixed costs and taxation are discussed in the theoretical framework. From outlines of static one –period model one concludes that this is rather a short run model of firm behaviour so there are further restrictions on the model with no allowances for inventories assumed.

Aiginger (1987) in his general propositions compares results of analogous certainty and uncertainty case and finds an additional component to marginal cost in uncertainty case. Depending on the sign of the additional component it may result in lower optimal production. Economic rationale for the finding as justified by the author is driven by the fear of overproducing and not meeting the actual demand or making potential losses on deficient supply. Previous studies in the field are differentiated based on the assumption of the firms' utility functions, risk attitude, market structures where they operate, and uncertainty sources. This all will be determinable by the sign of the marginal cost component and its additive effect on the optimal output.

Sandmo (1971) considers a model similar to the one discussed with addition of perfect competition assumption and assumes uncertainty comes from price level. Contrary to usual certainty case, solution for optimal competitive output lies where expected price exceeds marginal cost, this comes in line with the Aiginger(1987) finding of an additional component to marginal cost. Sandmo (1971) criticises the primitivism of profit maximising objective as market share expansions, investments are of no less importance to firms. Further assuming Arrow-Patt utility functions, decreasing sensitivity of the firm to even an infinitely small rise in fixed costs (tax rates) has been established as it departs from absolute risk aversion to a relative one. Baron (1970) finds that risk attitude of a firm is central to determining the firm's behaviour under uncertainty as it affects its short-run supply function structure, changes fixed costs and tax level effects on output. He was one of the first to derive the additional component to marginal cost in the uncertainty scenario. As risk attitude is central to his research model, he associates this component to the risk premium part of marginal cost. The risk premium becomes a larger positive addition to marginal cost once a firm becomes more risk averse, thus increasing the price level and decreasing output production. Further, he derives that under risk aversion firms' market clearing output is below its efficient level. Under the assumption of risk neutrality, firms would produce at a Pareto optimal level in the uncertainty case, once we depart from this assumption output level changes. Aiginger (1987) further generalises perfect competition case analysis by adding more restrictions to the utility function. His research distinguishes between risk neutral, loving and averse behaviour of firms' under uncertainty. He finds that a risk neutral firm's output level is equivalent to the certainty case, but a risk loving firm's output will be larger than market clearing output under perfect competition. Risk-averse scenario analysis and outcomes are consistent with the ones of Baron (1970) and Sandmo (1971).

The optimal output solution will differ in the case where uncertainty is coming from demand side fluctuations. It should be noted that this uncertainty scenario has more realism as a fixed price level can be explained by price rigidities, then firms have to decide how much to produce without prior assurance of the demand level. Hymans (1966) discusses firm's supply of output, by building a set of optimal output response functions to changes in price level. Adapting Lerner's Index to the uncertainty case of a price taking firm with a non decreasing marginal cost function, he derives function of output whose values lie within unity interval and output ranges from 0 to infinity. Based on the novice index interpretation, Hymans (1966) proves that optimal output in the uncertainty case is bound by the competitive certainty output independently of the nature of marginal utility function. Further this result together with Lerner's framework has been used to describe demand and optimal supply response functions' behaviour in the uncertainty case. Aiginger (1987) results are built on Hymans (1966) model and are guided by an individual's expected utility function. An additional positive component to marginal costing has been derived therefore proving that certainty optimal production output is higher than in uncertainty case, which is similar to Hymans (1966) result. Distribution of the optimal output results according to risk attitude is as follows – risk loving, risk neutral, risk averse firms.

The theories that have been considered here are sometimes criticised for their theoretical framework consistency. The assumption of uncertainty coming from demand side fluctuations seems contrary to the fundamentals of perfect competition, as it violates the postulate of the competitive model – producers can sell all of their produce at marginal cost price (Hey (1979)). So a natural choice will be to turn to a monopoly model under uncertainty.

Mills (1959) considers a single commodity market, where output and price decisions are made simultaneously "ex ante" based on a demand function that includes a stochastic uncertainty intercept. It has been derived that monopolist behaviour would be largely dependent on marginal cost curve structure. Under constant marginal costs, price charged by a monopolist in uncertainty case is lower than in certainty case, assuming no price discrimination exists. Once marginal cost behaviour changes - it is harder to generalise results, as price behaviour will be dependent on output, expected demand and realised demand interrelations. Intuition behind short run scenario is extended to cover longer horizon cases and it has been concluded that monopolist pricing behaviour would be more modest in the uncertainty case. However, this conclusion is not universal and will be invalid once monopolist production is at its capacity level then price level in uncertain case may be well above the certainty case price level.

Baron (1971) reconsiders Mills (1959) model and supports his results. It has been underlined that assuming total linear cost function monopolist firm would sustain its production under uncertainty as long as the price it charges exceeds marginal cost. This explains why a monopolist would consider maintaining production at a lower price level under uncertainty and defines price level boundaries. In addition, he finds that risk aversion in this model affects both price and production level. However, if we hold price fixed then optimal output will be inversely related to the risk aversion index.

Baron (1971) introduced two alternative models of monopolistic behaviour under uncertainty to consider. The first strategy, called pricing strategy, is where price is set fixed by the monopolist and output is produced once the demand is known. Second strategy mechanism is similar to the first one, but instead of price - quantity is fixed and price charged is determined by equilibrium once demand function is known. Defining quantity elasticity of expected demand function and using Taylor expansion series optimal conditions were found. Results for pricing strategy are in line with previous studies on the firm's behaviour under uncertainty, and an additional term to marginal cost has been found. This additional term in the marginal cost, if total cost function is non-linear, causes divergence of optimality results in certain and uncertain cases. Analogously, production strategy optimal conditions have been derived using Taylor series expansion and price elasticity of expected demand. Here, no divergence in optimality conditions has been found as expected profits and output levels are the same in both certain and uncertain cases. Even more to add, first order conditions of a monopolist firm using production strategy discussed above are the same as for a perfectly competitive firm under uncertainty. Choice of a strategy to employ by the monopolist will be guided by his risk attitude, as will be dependent on expected profits-utility functions.

Leland (1972) builds his analysis on behavioural modes constructed in Mills (1959) and Baron (1971). In contrast to the previous studies he uses a more general definition of uncertain demand function where an uncertainty term can exhibit either the additive or multiplicative nature. The paper's technical side relies on the principle of increased uncertainty (PIU). It has been used to derive the results discussed here. Monopolistic firm behaviour under uncertainty will be dependent on the strategy followed and the firm risk preference. Leland (1972) introduces additional determinant to the list - dispersion of profit caused by alterations in price level or demand function. The study illustrates combinations of different conditions for which output and price under uncertainty will depart from the certainty optimal output and price levels. Output level will not be altered by uncertainty only for a quantity-setting risk-neutral firm, and in the case of price setting monopolistic firms - price level will not be affected by uncertainty in a case of risk neutral firm with constant marginal cost. Firms will not be indifferent in their mode of preference. If choice is given, they will be willing to make price and quantity setting decisions ex post, once more information is available. This gives intuition behind firms' choice in favour of price or quantity setting behaviour rather than Mills (1959) strategy, as they will try to reduce if not eliminate uncertainty components from the decision making process. Validity of PIU property of demand function has been questioned and led to polemics in the literature. Korkie (1975) using random coefficients model of risk proves that PIU property of the demand function does not hold. Leland (1975) in his reply to Korkie (1975) shows that many linear stochastic demand functions do follow PIU property consistent behaviour. His rethinking of Korkie (1975) comment concludes that rather than PIU property questionability one should reconsider the linearity assumption of the stochastic demand function. More recent study of Hau (2004) on example of quantity setting firm under Leland type of uncertainty shows that PIU assumption of demand curve can be easily violated and derives necessary and sufficient conditions for the Leland (1972) optimisation results to hold.

The theoretical findings of studies discussed above suggest that in most cases output decisions and pricing behaviour changes under uncertainty. If firm's objectives align with the ones of their shareholders, who are asset holders, then risk aversion is more realistic assumption about a firm's utility function. Under the assumption of risk aversion output per firm declines under uncertainty. So how is it translated to industry as a whole? Lippman and McCall (1981) considered a static model of uncertainty effect on the competitive industry. It has been found that as output per firm declines, additional free capacity in the market arises and it would accommodate new firms into the industry.

From the studies considered so far, one concludes that uncertainty distorts equilibrium price and output levels in most cases of perfectly competitive and monopolistic firms. Not only will the absolute levels of optimal conditions change, but also the whole mechanism behind a firm's operation shall be reconsidered. The impact of fluctuations in fixed costs and level of taxation/subsidy on firm's operations will differ compared to the deterministic case (e.g. Sandmo(1971), Leland (1972) and Baron (1970)). This is the only general consensus that has been agreed by the studies. Unfortunately no more generalisations can be highlighted, as further firm's decision-making is individual and can be characterised by many other factors. The magnitude and direction of change in a firm's behaviour will be guided by firm's objectives, risk attitude, properties of demand function and how uncertainty enters it.

A one period static model gives useful framework to consider short-term behaviour of firms under uncertainty. The validity of the results in the longer run and the firm's production process is as well of interest, especially once restrictive assumptions of no inventories and adjustment costs have been lifted.

Uncertainty effect on optimal output and price determination will be translated to factor input choice. For risk averse firms, a decrease in output will be followed by a decrease in demand for factors of production, if firms are risk neutral then there will be no effect on output level or input choices. (Sandmo(1971)). Zabel (1973) develops a multi-period discrete model of a competitive firm's production process, where capital and labour inputs are not substitutable. Assuming that both factor inputs choices are done prior to actual sales price is realised, then associated uncertainty leads to higher capital stocks, if storage is accounted for. This comes through as the result of an expected profit maximisation problem, as higher capital stock would be accounted for higher expected profit.

Hartman (1976) offers an alternative model to discuss the uncertainty effect on factor demand. He assumes a price taking risk neutral firm whose labour input is variable but whose capital is quasi-fixed. Decisions on the amount to produce and number of workers to hire are done once the market price has been realised, but decisions on how much capital to employ is done under output price uncertainty. This model of firm's behaviour is more flexible as firm has one variable input, in particular labour, that can be freely adjusted according to market conditions. It can be used to compensate for 'ex post' bad decision making for the choice of capital input. Demand for capital input will be linearly guided by behaviour of partial derivative of short run profit function to capital. So an increase in the partial derivative will result in an increase for capital input. The effect of uncertainty on demand for labour inputs will be indirect - passed through a firm's decision for optimal capital level. It will depend largely on the degree of substitutability between labour and capital inputs in the production process. Once capital has been installed there is no flexibility in substitution between capital and labour inputs, so Kon (1983) restricts the model by fixing the capital to labour ratio. Ex ante, capital-labour ratio has been chosen together with capital level and only then ex post labour input level determined. It has been derived that under uncertainty firms will tend to use more labour intensive capital, as there are no labour adjustment costs due to the flexibility assumption. However this will come at the expense of lower expected wages.

Pindyck (1982) goes further in the field and extends the existing model of Hartman (1976) by not only introducing adjustment costs but also giving an option for inventories. Uncertainty comes from a stochastic future demand function that is constructed in a way that uncertainty grows with an increase in time horizon of events. The analysis is built on the construction of the phase diagram of investments and capital by the means of solving partial differential equations using stochastic calculus. Phase diagram captures production process mechanism and its deviation from equilibrium once conditions change. The results suggest that the level of adjustment costs will guide behaviour of firms. If marginal adjustment cost is rising at an increasing rate then target capital stock and output level will be higher under uncertainty. If marginal adjustment cost is rising at a decreasing rate then uncertainty will have supressing effect on capital stock. Capital stock and output levels will be the same in both uncertain and deterministic cases under the condition of marginal adjustment cost rising at a constant rate. Deviation of the results from deterministic model arise as marginal adjustment cost rising rate of change becomes non-constant as continuous adjustment to stochastic demand fluctuations leads to continuous alteration in firm's cost functions. In a case where marginal adjustment cost is rising, quasi-fixed cost of capital adjustment creates incentive in firms to opt for more capital stock. From one side increase in capital stock will help firms to buffer the uncertainty effects in the market and will force them to produce more. However, due to on-going maintenance costs, the associated profits will be reduced. The use of inventories can slightly reduce the impact of uncertainty on firms in absolute values, but generally speaking, the results, in terms of mechanism of relationship between variables of interest, will not change. It has been shown that firms will still tend to use inventories even when their capital is at the optimal level.

In terms of uncertainty in the production process, it is common for uncertainty to come not only from output price level or demand function, but also from input prices i.e. capital cost or wages level. Pindyck (1982) addresses this issue by reconsidering his production model for price for input uncertainty. He concludes that wages uncertainty effect on a firm's operations is the same as that of demand uncertainty. Once uncertainty is correlated and coming from both production inputs it will magnify its impact on output, as adjustment costs will proportionally increase.

2.1.1.2 Investment decisions under uncertainty: entry and exit conditions

So far the primary focus of discussion has been operations of firms under uncertainty in existing market conditions. However, there are other not less important decisions managers and shareholders would be concerned with. For instance, the size of firm's market share increase can be achieved by entering a new market or just by gaining a larger market share in the current one by means of investment. However, there are cases when a shutdown option would be more desirable.

Dixit (1989 a) discusses the concept of adjustment costs and its importance in market entry- exit decisions. Studies draw parallels between investment options valuation and labour market decisions. Decisions regarding choice of a particular option/strategy are guided by the Net Present Value rule (NPV). NPV criterion to invest implies that expected discounted profit from investment should at least cover the initial sunk costs used to set up investment. The idea behind this is that due to a project's fixed costs firms experience some lags in their adjustments followed by news. This behaviour is explained by the sunk cost recurrence after withdrawing from a current project. If an investor is willing to undertake it again. If an investor has not undertaken the project yet, then he is more likely to choose an option to restrain in the presence of increased uncertainty. High adjustment costs imply larger required returns to investment in order to choose the option of entry and much lower returns to leave the project once in. Therefore, in a case of increased uncertainty required values of return to investment for entry and exit conditions will have a wider wedge than in a general case. This argument is straightforward as for bearing additional risks investors will require higher returns to undertake investment, and it pushes up criterion for entry. On the other side, increased exchange rate volatility lowers the criterion for decision to exit investment as it increases the probability of currency arbitrage. Therefore, exchange rate uncertainty has an adverse impact on the firm's decisions to enter into an investment project. The result is idiosyncratic and we cannot make any industry wide conclusions based on it.

Spencer and Brander (1992) consider a discrete model of Stackelberg and Cournot equilibrium changes in a duopoly under uncertainty. Standard deterministic models of oligopolistic behaviour have been replicated assuming additive demand uncertainty to see how uncertain case equilibrium deviates from the Marshallian case. Further restrictions on the model of linear demand function, identical and constant marginal cost curve structure, and positive output by both firms have been assumed. The Stackelberg model gives a first mover advantage to the leading firm to enter the market, only once the leader has been assigned a market niche in the first period will the follower make entry into the market. However, if neither of the firms choose to commit in the first period then the solution of the Stackelberg model is reduced to a Cournot scenario. The choice in strategy in a duopoly has been viewed as a trade between commitment that the Stackelberg model presents and flexibility that the Cournot model offers. Under uncertainty the leader's output and expected profit are not affected by uncertainty, but realised profit is. Under Cournot conditions, uncertainty enters both output and expected profit functions. However, Cournot option is viewed as a more valuable option under uncertainty than in the deterministic case as expected value of profit is an increasing function of uncertainty. This is a result that has been expected, as under imperfect information firms may be reluctant to enter, since a "wait and see" strategy offers the option of more informative decisions, especially in a market with higher volatility. Authors derive a benchmark volatility value that will make firms indifferent between the options of precommitment and "wait and see". Further analysis show that under uncertainty both firms will not deter from entering the market, as marginal costs are identical for both firms and both firms are profit maximisers. Introduction of shutdown probability only forces a strategy preference towards a Cournot behaviour solution. These results will only be amplified if we lift the assumption of risk neutrality of agents in favour of risk aversion.

We have looked at a strategic interaction of two firms under uncertainty, but are the results of Spencer and Brander (1992) universal or dependant on the number of firms in the market. Smit and Ankum (1993) use a game theory approach to derive optimal investment strategies for firms operating under conditions of monopoly, duopoly and perfect competition market structures. Under assumptions similar to that of Spencer and Brander (1992) their findings are in line with the previous studies. Additionally, they find that in duopoly where the net present value of a project is low and cooperation is an option both firms will defer their investment and invest simultaneously once uncertainty is resolved. If cooperation is not an option, firms will enter the market simultaneously before uncertainty is resolved, even though this strategy does not produce a Pareto efficient outcome and it is second best to a coordinated strategy output. Results of monopoly and perfect competition scenarios are contrasted, as in monopoly exclusive market power rights give advantage of no market share loss associated with investment deferment. Under uncertainty a monopolist will benefit from postponing entry to the market and making a more informative choice if the project value is small. The postponement of investment under perfect competition can result in pre-emption of the market by the rival firms. So uncertainty and fierce competition will force firms to invest early so that the project value would not be eroded.

The results will change once we alter investment characteristics from assuming incremental outflows to one lumpy sum sunk cost with consequent payoffs in the future. Bouis et. al. (2009) uses continuous-time investment model to describe investment behaviour of three symmetric risk neutral firms in oligopolistic competition under uncertainty. Uncertainty is modelled by assuming exogenous multiplicative demand shock. Market share impact on profits is passed through demand function that is non-negative and decreasing in the number of firms operating in the market. The problem of the strategic interactions has been solved following backward induction and concludes with the existence of two equilibriums. For sequential equilibrium to exist there should be investment trigger values for all firms that will give them incentives to enter sequentially. A rise in uncertainty leads to higher required levels of investment triggers, as firms will refrain from entering the market when volatility is sufficiently high. In case of the third firm investment trigger levels is inversely related to market share when three firms are operating. This is explained by the assumption that a rise in market share is reflected in demand function and this in turn projects onto profit function. Not surprisingly, higher returns associated with investment lead to lower investment triggers. Following the same logic, the investment trigger level for a second firm to enter the market is inversely related to market share payoffs in a case where there are two firms operating. What about investment trigger function of market share payoff when three firms are present in the market? If market share payoff increases when three companies are at the market, it becomes closer in value to market share payoff when two companies are present at the market. This convergence in value will make second firms more indifferent between entering the market second or third as payoffs will be converging to unique value and pre-empting threat of the market by third firm will be viewed as less credible. Thus, in contrast to “devaluation” of the commitment option, investment deferment becomes a more valuable alternative, thus increasing the value of the investment trigger. Identically, first mover investment trigger level function will be inversely related to market share payoff when one firm is present in the market, and will be decreasing function of market share payoff when there are two companies present in the market. How is the investment trigger of the first mover related to the market share payoff when there are three firms in the market? It is decreasing. If profitability of a market share with three agents increases then a second firm will delay its entry into the market, as a higher investment trigger value is required. Thus, the first mover will enjoy its exclusive rights to the market for longer, higher expected profits will lead to a decrease in investment trigger. This effect of investment threshold levels moving in one direction between first mover and third entrant and in opposite direction between first mover and the follower has been defined by the authors as an “accordion effect”. Simultaneous equilibrium implies strategy where the first two firms invest simultaneously followed by the third. Existence of multiple equilibria has been blamed on the “accordion affect” that arises as a consequence of uncertainty. Departing from the oligopolistic case by increasing the number of firms, results are generalised to N-firms in the market. A generalised “accordion effect” creates an asymmetric impact on the investment threshold values among odd and even market entrants in uncertainty. It has been confirmed that for N firm case all investments will be delayed with increased uncertainty, but the number of firms will have an impact on investment entry due to the “accordion effect”. First mover will be willing to commit to investment sooner if the market is characterised by an even number of potential entrants. Another implication of the effect is that fierce competition will not force firms to enter the market immediately instead it increases the option value of refraining. Thus, markets with a smaller number of firms will have lower investment triggers and earlier entry to the market. These results are of opposite direction to the results of studies where investments are assumed to be incremental. Will the monopolist behaviour change when investment is a lump sum rather than incremental?

A further study of Siddiqui and Takashima (2012) uses a model very similar to Bouis et. al.(2009) with one innovation of investment structure. Investment is to be done in two sequential periods. Sequential model gives an option of flexibility to economic agent, where firms may enter the market by investing in the first period and then expand its market share by making a further irreversible investment. Alternatively one can make lump sum investment in one go, rather than in two steps, and get a larger market share directly. This particular strategy is referred to as a direct approach and is a setting of Bouis et. al.(2009). It has been found that monopolist firm investment trigger in the direct approach is an increasing function of uncertainty and investment cost. So, monopolist's value of waiting is higher under uncertainty.

2.1.1.3 Trade

- *Exchange rate volatility – trade link*

Debates regarding the impact of exchange rate volatility on trade flows have been in the literature for a while. However, no general consensus was achieved regarding the matter. One of the early papers is by Clark (1973) who proposes a theoretical model for the analysis. A perfect competition model is assumed with a single export-orientated firm producing a homogenous product that cannot be sold on the domestic market. Therefore, it adapts price-taking behaviour and obviously has no impact on the foreign price of a good or exchange rate. A fixed non-stochastic production function is assumed that is independent of imported inputs, thus there is no currency risk involved in the production process. The only uncertainty, that firms face, is the exchange risk component of output price, which is translated to profits function. It has been argued previously that the availability of forward markets eliminates the uncertainty associated with exchange rates. However, it is not always the case. Clark (1973) compares models with imperfect and perfect forward markets and finds that the uncertainty component persists in both variations if one assumes that the utility function is quadratic. Assuming entrepreneurs are risk-averse, Clark (1973) proves that for them to sustain an original supply of exports under greater exchange rate volatility, a compensation for the higher risk is required, i.e. higher price for exports. This is achieved by decreasing production output, thus reducing export volumes as a consequence.

The author points out that foreign exchange risk exposure can be diversified if to introduce import prices into production function or extend firm activities to domestic market operations. The presence of an imports component in the production process will reduce exchange rate exposure. If domestic currency appreciates, even though output price decreases, input prices will decrease proportionally to the reduction in import prices. Therefore, the reduction in costs will reduce the rise in output price effect on profit and revenue functions. If to remove the output market restrictions and consider the case of operations in multiple markets, including domestic market, entrepreneurs will have an option to switch between markets and diversify the currency risks (Akhtar and Hilton (1984), Cushman (1986)).

Ethier (1973) reiterates the arguments from previous studies on why forward markets are not fully clearing the risk. These relate to the poor development of the forward markets, risk premium associated with the forward cover and the gaps in export, as well as import prices perceived by exporters and importers (Ethier 1973, p.494). A model where objective is an importing firm that faces uncertainty through input component prices is assumed. In contrast to previous studies (i.e. Clark (1973)) Ethier (1973) relaxes the assumption of perfect competition therefore letting a firm choose its pricing strategy. Additionally it is assumed that the utility function the firm faces is that of Von Neumann-Morgenstern nature. The study supports the conclusions of Clark (1973) that exchange rate volatility reduces trade flows, in this particular example of imports. It extends previous conclusions by proving that this statement disregards the risk nature of the entrepreneur. Risk nature influences only decision of how much forward cover to purchase in order to hedge the risk but not the volume of trade. De Grauwe (1987b) divides the uncertainty effect on profits to income and substitution effects. He claims that some entrepreneurs can be attracted by higher volatility of exchange rate as it can yield higher expected returns and would choose not to purchase any cover. Brol and Hansen-Averlant (2010) demonstrate that once the degree of risk aversion is less than unity and firm employs a strictly concave production technology, it will be sufficient for a positive relationship to exist between exchange rate volatility and domestic production (and consequently labour demand). Condition of risk aversion being less than unity is sufficient for substitution effect to prevail the income effect.

Further studies in the area by Hooper and Kohlhagen (1978) are built on the model of previous ones, but with a number of modifications. They bring together importer and exporter sides into the analysis to account for the general trade flows in the economy and control not only for volumes of trade but for its prices too. Derived equilibrium conditions for price and quantity are dependent on the exporters' and importers' exposure to currency risk. Further theoretical investigation has shown that distribution of the effects among price and volume of trade depends on importer's elasticity of demand and differs depending on the risk nature of entrepreneurs.

According to studies described so far, the volatility of exchange rates has adverse effects on trade flows, which are invariant to the invoicing currency. Under the assumption of risk aversion, an importer's demand for goods will be less the more volatile are the exchange rates and they will try to switch to alternative domestic supplies, thus reducing the trade flows. If invoicing currency is the domestic one then foreign exporting firms will bear the exchange rate risk. Thus under risk aversion, they will be more reluctant to export goods in the same quantities and would opt to reduce the volume of exports and produce more for the domestic market. The use of forward markets to hedge for the currency risks will distort the equilibrium, as they are costly to business. Adding costs to operations firms will have to charge the premium prices to consumers thus reducing the volume of trade.

The need for adapting a long-term time horizon approach in the studies can be justified by the presence of sunk costs in the business operations. Firms are more sensitive to the long-term variations in the exchange rates, rather than short-term variations due to adjustment costs. Dixit (1989a) defines general market entry-exit rules. For a company to enter the market expected turnover should exceed the sum of variable cost and interest, for the exit company's revenue should be less than variable cost deducted by the interest on exit. Kroner and Lastrapes (1993) support the view of Dixit (1989a), and suggest that in the presence of relatively large sunk costs potential market participants will choose not to enter the market under exchange rate volatility. However, what if the firm is already in the market and its current turnover falls in the gap between the exit and entry barriers, and covers only the variable costs? If each time to enter the market company has to pay some fixed costs to set up operations, firms will be better off by opting for the wait and see strategy. According to Dixit (1989b) this creates "hysteresis" in the trade that gives rise to unintentional dumping strategies. Under exchange rate volatility, there can be misalignment between costs of production and cost of the good to the market. As there is a time wait for the good to be manufactured before it actually reaches the market, two costs have to be accounted for in separate periods.

Franke (1991) develops the established model by adding the rigidities of transaction costs, i.e. entry and exit costs to operations. Model and economic setting is very close to the Dixit (1989a) "option value of waiting" model however it assumes that volatility follows a mean reverting Ito process rather than a Wiener process. Under these assumptions, trade volume and capital mobility have a deterministic impact on the exchange rate. The paper considers the option of entering and exiting foreign markets for firms with comparative advantage and disadvantage under the assumption of risk neutrality. Firms operate under no administrative barriers and in a continuous time horizon, i.e. long-run model. Then according to Franke (1991), the law of one price failure creates misalignment in relative prices and gives arbitrage opportunities for the firms depending on the cost of entry and exit barriers. Exchange rate volatility widens the gap between relative prices. Thus disadvantaged firms may be better off if their expected value of profits grows with exchange rate volatility at a higher rate than transaction costs. This is not necessarily the case for advantaged firms. If this was the case for all firms then the volatility of exchange rate would induce positive effects on trade by prolonging the period of firms operations and increasing the number of firms.

Sercu (1992) looks at a short-term model where the rigidities to operations are created by tax duties, tariffs and transportation costs rather than entry-exit barriers. No deterministic impact of trade volumes on the exchange rate is assumed. It is a two period decision model. In the first period a decision is made regarding the production function, and in the following period a decision is made to operate in domestic or foreign markets. The analysis of the model author differentiates between importing and exporting sectors and assumes there is no switching from one sector to another. Surprisingly for the competitive and pure monopolistic models, analysis yields two similar results. Exchange rate variability will have a negative impact on production and prices in the importing sector, whereas the exporting sector effect of variability will be inverse in nature. This result is explained by the presence of an "autarchy price cap" (Sercu (1992, p.584). Prices cannot be pushed higher than the autarchy ones in the importing case and cannot be pushed down lower than the autarchy ones in the exporting sector. Since then the opportunity cost of trading increases in favour of domestic market operations. Despite strong results for the two extreme cases, for the intermediary case author's findings were rather mixed.

- *Trade-unemployment link*

It is hard to underpin the trade unemployment relationship directly to one of theoretical fundamentals, as the first one is viewed as an attribute of microeconomics and the latter as a macroeconomic phenomenon. Conventional trade models are based on the assumptions of a competitive model and are valid only under the assumption of full employment. Therefore, for a long time economists neglected the link. However, recently some studies tried to modify the orthodox models by relaxing the assumptions of full employment. (e.g.

Davidson et. al. (1999)). Unfortunately, existing literature on trade-unemployment relationship is not as rich as one would like.

Kruse (1988) looks at the problem from the idea that open trade brings higher competition to the domestic market participants. Layard et.al (2005, p.391), in their wage-price setting model, show that under increased competitiveness wage-setting and price setting schedules are shifted backwards, therefore lowering employment level and wages in the long run. The study of Kruse (1988), however, is more concerned with the following labour force adjustment to increase in unemployment through increased competitiveness. He identifies in his study three hypothesises on how the adjustment process of those who became unemployed through increased trade will differ from the rest. They are “demographic selection”, “unemployment congestion” and “industry decline” (Kruse (1988, pp.402-403)).

The first hypothesis is straightforward as for some sectors the outlay of labour will be demographically specific. For example, redundancies in labour intensive metallurgy production are usually associated with increase in male unemployment. In turn male low-skilled employees generally could have longer tendency to adjust to the new market conditions. Unemployment congestion hypothesis implies that unemployment may be specific to geographic areas. This can be shown by the example of a town that is characterised by a large dominant employer, like a metallurgy producer. Then due to high redundancies in the plant it will be harder for the unemployed to find alternative sources of employment and they will be facing tougher employment competition. Third argument, “industry decline” hypothesis raises the issue of depreciating human capital. When some part of the sector, largely outsourced overseas, the unemployed who posses specific skills to production lose their human capital due to the loss of demand for their skills.

Ravenga (1997) studies the effects of free trade on unemployment and wage levels for the Mexican case during its transitional years to open economy of 1984-1990. The author uses a bargaining model as a foundation for the analysis where employment will be determined by the firms labour demand function. It is assumed that the trade will affect the employment level in the model by shifting output and through wages, where higher wages are associated with higher unemployment. The study concludes that trade liberalisation had a depressing effect on the employment level and wages by reducing production, and rents available to firms and workers.

Davidson et. al. (1999) extends the conventional Ricardian trade model to include an equilibrium unemployment rate. On this assumption authors modify Stolper-Samuelson Theorem and Specific Factors model relative to employment factors. A two-country bilateral trade model is assumed where one of the partners is a larger, capital abundant economy with a lower aggregate unemployment. The authors prove that under the framework described larger country will suffer welfare losses from trade in terms of lower aggregate employment but will experience gains in terms of higher idle capital.

2.1.2 Empirical foundations: Facts of macroeconomic volatility effecting firm's operations.

- *Pricing behaviour, output determination and borrowing.*

The direct impact of volatility on a firm's production and operation decisions results in production, price and cost levels uncertainty. Output price uncertainty will have impact on charging margins determined by resellers and will alter their behaviour. Schroeter and Azzam (1991) in their study of US hog packing industry over the period of 1972-1988 found that the impact of output price uncertainty was higher on firms behaviour than market structure or power. It has been found that the uncertainty element has a depressing effect on margins and can even swing pricing behaviour towards a competitive outcome under an oligopolistic environment. Demir (2009), using the example of Turkey during a 10 years period from 1993, concludes that volatilities have a negative effect on profits – 10% increase in inflation volatility reduces operating profits by 2.1%. The effect of exchange rate volatility on operating profits is positive, but insignificant. However, in a case of total profit function, both variables have the same directional negative impact and high significance. The presence of financial assets softens the unfavourable outcome.

Most equilibrium pricing models (i.e. Cournot, Dixit-Stiglitz and Competition on the Circle) predict that import prices are sensitive to currency appreciation. However, the strength of the effect depends largely on the degree of competition and the number of domestic and foreign firms in the market (Dornbusch (1987)). Prasertnukul and Kakinaka (2010), in their study of exchange rate effects on price level for Indonesia, South Korea, Philippines, and Thailand, found that the volatility of exchange rate is largely passed to producer, rather than consumer prices. Caldentey and Haugh (2009) in their study of the supply chain between two firms (supplier and producer using Stackelberg game model) find that producers are likely to charge premium prices to liquidity-constrained retailers. Another result of the analysis implies that under flexible contracts with hedging, the supplier is likely to shut down the supply chain by charging abnormal prices. Strategy for a firm to keep its operations is to switch its budget from low demand to high demand states. However, this opportunity is not valid under financial constraints.

Kandil (1992) extends model of output and pricing behaviour to include empirical research on 11 industrial countries (Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, UK and the US). It has been found that interest rate volatility has a negative effect on real output in all countries being researched. Results are significant for all countries except for the Netherlands call money rate, and the government bond yield of Switzerland. In line with a depressing effect on output for some countries (Canada, Denmark, Italy, Japan, Netherlands, Sweden and the US) interest rate volatility had a cumulative effect on the price level. Findings of Fountas et.al.(2006) on the inflation uncertainty effect on output growth are in line with the general Friedman hypothesis. Inflation uncertainty has a negative effect on output growth in the G7 countries except for France and Italy, where output is approximated as industrial production index. Furthermore, the study of Aghinon et.al (2009) examines productivity growth in eighty-three countries during the period of 1960-2000. Research shows that exchange rate volatility has a depressing effect on productivity growth in countries with weak financial development.

Macroeconomic volatilities destabilise the banking sector and impose financial constraints on firms' operations and developments. Elyasani and Mansur (1998) in a study of fifty-six commercial banks, whose stocks are traded on New York and American stock exchanges, have found an inverse relationship between interest risk and stock returns. This result contradicts financial market theoretical postulates of higher risk association with higher returns, but this can be the case in real world. An example could be investors during uncertain times making investment into assets with prospects of value growth rather than yield generating. A further research of Kasman et.al. (2011) confirms a negative relationship between interest rate volatility and bank stock returns on a sample of fourteen banks whose stocks are traded on the Istanbul Stock Exchange. Interest rate volatility has significant negative effects on bank stock returns in six cases, whereas positive significant relationship with bank stock returns volatility has been confirmed for all fourteen banks. Exchange rate risk effect on stock returns is of a lesser power, as negative significant relationship has been suggested only for five banks. Similarly positive impact of exchange rate risk on stock return volatility has been confirmed for nine out of fourteen commercial banks. Adverse conditions in the banking sector affect their ability to borrow translating it to consumers through the supply of credits. Valencia (2013), using data on US commercial banks from 1984 to 2010, suggests that uncertainty leads to lower loan growth with smaller size of capitalisation banks being hit hardest.

Volatility adversely affects profits, pricing strategy, investment, cash flow, balance sheet activities, and borrowing. The distortion of optimal equilibrium conditions reflected in amendments to capital/labour input decisions altering employment level. Firms facing uncertainties would prefer hedging options where they are available, but they are costly creating extra cost components and market rigidities. Current trends dictate that even small sized firms are actively managing exchange rate risks where possible (Papaioannou (2006)). Solakoglu and Demir (2009) show for a Turkish case that most firms successfully protect their operations from exchange rate risk exposure that depreciates firms' value.

- *Trade*

The impact of exchange rate uncertainty on export and import functions determination has been identified by a number of studies under conditions of open economy and free trade (Arize et.al (2008), McKenzie and Brooks (1997), Pozo (1992), Qian and Varangis (1994), Sauer and Bohara (2001)). Continuous adjustments in export or import functions imply variability in demand schedule, costs of production and changes in pricing behaviour.

Empirical results of exchange rate volatility effect on trade are sensitive to the type of volatility measures, nature of exchange rate measure, number of countries and framework model used.

The study of Akhtar and Hilton (1984) used the standard deviation of daily observations of effective nominal exchange rate index within three months periods. Effective exchange rate index was obtained by trade weighting bilateral exchange rate of nine trading partners for the US and thirteen for Germany. It has been fount that, during the period of 1974 to 1981, exchange rate variability has reduced the volume of trade. Gotur (1985) used standard deviation of daily observations within each quarter to measure volatility of exchange rate. He extends Akhtar and Hilton (1984) study to include bilateral exchange rates for 18 industrial countries over the period of 1973-1984. Findings question the robustness of previous results, as no adverse effects of volatility on German import volumes or export/import prices have been found. However, adverse effects of volatility on German export levels have been recorded together with positive effects of volatility on the US export volume. Similarly, positive effect of exchange rate volatility on the US export prices has been found that could indirectly lead to decrease in export volumes.

The study of Bailey et. al. (1986) looked at the relationship between exchange-rate variability and trade performance of the big seven industrial countries (Canada, France, Germany, Italy, Japan, U.K., and the U.S.) during the period of 1973 Q1 to 1984 Q3. The choice of the data period is not random, and has been done because of two reasons. First, 1973 is the official abandonment of Bretton-Woods system. Second, as some of the countries already allowed their exchange rate to float prior to the breakdown of the fixed exchange rate system, there were no data points lost during the derivation of the volatility measure. Volatility measure used was absolute value of the quarterly percentage change in the nominal effective (trade-weighted) exchange rate. Contrary to the findings of Akhtar and Hilton (1984), this study has not found any evidence for the negative effect of exchange rate variability and trade. Authors explain it by the time period that has been chosen, and blame adverse effects of trade on exchange rate regime rather than volatility of it.

Kenen and Rodrik (1986) proposed three measures of short-term exchange rate volatility based on the assumption that economic agents are risk averse (i.e. all of the measures are quadratic). First they use moving sample standard deviation of the monthly percentage change in exchange rates. Second and third measures are based on residuals collected from a log linear trend equation and a first order autoregressive equation respectively. All of the measures have two variations for 12 and 24 months and employ the real effective exchange rate index, derived by deflating bilateral rates by consumer-price indexes. The ten countries covered by the study are: US, Canada, Japan, Belgium, France, Germany, Italy, Netherlands, Sweden, Switzerland, and UK in the quarterly range of 1975 Q1 through to 1984 Q3. When deriving the exchange rate indices countries are treated symmetrically and depend on a common in sample set of bilateral rates. Depressing effect of exchange rate variability on trade volumes has been found where 24 months based measures gave more significant results than the 12 months ones.

Perée and Steiner (1989) used a volatility measure based on the maximum and minimum values of nominal exchange rate alone, with an improved measure that uses the integral of misalignment, and thus takes into account the duration of spread. For the equilibrium value of exchange rate they used equilibrium rates computed by Williamson (1985). The empirical estimation of export equations for the industrial countries (Belgium, Germany, Japan, UK, USA) is based on the annual data for the period of 1960 through to 1985. Maximum and minimum values are computed for backwards periods of 10, 5 and 3 years. Study concludes that it did not come up to a "proper" measure of uncertainty as none of the proposed measures denominate. However, this underlines the importance of past peak values in the measures and invites further research into the area for the measures to be improved.

Cho et al. (2002) used two volatility measures in their panel data research of agricultural trade determinants covering ten developed countries in the period of 1974-1995. The ten sample countries are: Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Switzerland, UK, and the US. Volatility of exchange rate was approximated by the moving sample standard deviation of the first difference of the real exchange rate over the prior ten years. A second measure used was a Perée and Steinherr proposed measure of volatility, V_t, where the equilibrium exchange rate was defined as mean value of exchange rate over the past 10 years. The measure is calculated using the bilateral exchange rates on a yearly basis with a memory of 10 years prior to observation. Regressions using both measures gave similar results - uncertainty has a negative impact on trade. However, the results based on the Perée and Steinherr (1989) measure were weaker in terms of significance and magnitude of coefficients.

Hooper and Kohlhagen (1978) studied the effect of exchange rate uncertainty on trade on the case of the US and German exports to a set of their trading partners – France, Japan, U.K., and Canada during the period of 1965 Q1 through to 1975 Q4. They used three volatility measures. First and second measures are 13 weeks moving standard deviation of the spot rate and forward rate. And third one is average absolute difference of the current spot rate and its previous period forward within the 13 weeks period. The latter one appeared to be the best indicator for risk, as it yielded the largest number of both the significant estimation coefficients and best-fit equations. Empirical results suggest that currency risk had a significant impact on price of tradables. However, this appeared to be insignificant in determining volumes of trade. One of the explanations for unexpected result could be presence of inelastic demand for imports and exports then changes in price would be associated with almost negligible changes in quantity. Thursby and Thursby (1987) in their study of 16 OECD countries and South Africa find that exchange rate variability adversely affects volume of trade. The volume of trade is significantly affected in most cases with its magnitude depending on the elasticity of demand and supply functions. As well, recent studies of Hudson and Straathof (2010) proved the negative effect of volatility on trade. However, they claim that after 1985, the negative effect of uncertainty on trade is diminishing because of developments in financial derivatives especially over the counter currency swaps.

Diminishing effects of uncertainty could be as well a consequence of production cost structures. Aabo et. al (2010) find that for medium sized manufacturing firms in a small open economy (here Denmark) imports play the role of substitutes for financial hedging. Furthermore, studies by Greenaway et al. (2010) for the UK during 1989-2004 find a negative effect of exchange rates on exports that is lighter in industries that import their production inputs.

Cushman (1983) extends the model of Hooper and Kohlhagen (1978) by enlarging the time span by adding the floating period. Negative effect of exchange rate variability on trade volume is found. The difference in results of the studies is attributed either to the use of real rather than nominal exchange rate or to the measure of volatility used. The studies of Thursby and Thursby (1987) found that mostly test results are indistinguishable between real and nominal volatility measures. Cushman (1983) finds that exchange rate effects on trade parameters tend to be lagged and uses a more long-term volatility to account for them. Akhtar and Hilton (1984) argue that it is not only the direct effect of uncertainty on trade that should be considered, and emphasise the need to consider the long-term indirect effects of exchange rate variability as well. De Grauwe (1987a) supports the view of Akhtar and Hilton (1984) and believes that exchange variability has prolonged effects on trade through its impact on protectionist policies. The more adverse is the effect of exchange rate variability on an economy's output and unemployment the higher will be the tendency to implement protection policies. Study uses long-run exchange rate variability to account for the changes in trade flows and demonstrates its negative effect on bilateral trade growth. It was found that around 20% of international trade slowdown from 1973 to 1984 is due to exchange rate variability.

Chowdhury (1993) used moving sample standard deviation of the growth rate of the real exchange rate, with lag length of 8 months. For the robustness test he also used alternative leg lengths of 4 and 12 months. Results based on both nominal and real exchange rates have been estimated. Study covers period of 1973Q1 to 1990Q4, after all the sample adjustments the estimation sample was reduced to 1976Q2 – 1990Q4. He finds negative effect of exchange rate variability on trade by the means of error correction models. They also blame the lack in previous studies of results significance for ignoring time series stochastic nature of the variables, for example not accounting for cointegration of series and stationarity.

Pattichis (2003) argued the legitimacy of previous results on long run relationships between exchange rate variability and trade. His argument is based on the difference in the econometric nature of the variables that permits them only to cointegrating short-run dynamics in special cases. De Vita and Abbott (2004 b) addressed the cointegration issues in their paper by employing the Johansen procedure and appraised the importance of the long-term volatility of exchange rate. The study finds that the volatility has a significant impact on the export function of the US to the rest of the world. However, the magnitude and direction of the effect is heterogeneous across different market destination.

A further argument on exchange rate variability effect on trade took a more technical aspect in the later literature. Major concerns are about the methodology of volatility estimation, addressing potential simultaneity bias and causality problems.

More advanced models have been used to address the volatility. For example, Qian and Varangis (1994) used a multivariate ARCH-M model to test the relationship of exchange rate volatility on trade (i.e. if changes in the exchange rate volatility directly affect the trade volume) to escape the spurious regressions critique. ARCH-M model was constructed using real exports, real export's price and exchange rate reduced form equations. In the first two equations, the exchange rate is included without any lag structure. It follows a random walk model and allows conditional variance measure to capture the unexpected volatility changes in exchange rate. The function of the conditional variance of one-step ahead exchange rate is included as an explanatory variable for real exports and price equations. Here the estimation is done using the iterative method rather than conditional log-likelihood functions and follows the Berndt et al. (1974) algorithm. The study covers data for Australia, Canada, Japan, UK, Netherlands and Sweden. It has been found that invoicing currency plays an important role in the direction of exchange rate volatility effect on trade. Exports invoiced in domestic producer's currency are positively affected by the exchange rate volatility, however once the invoicing currency changes to importers' then effect becomes negative.

Pozo (1992) studied exports from Britain to United States to analyse the effect of exchange rate volatility on trade in annual period range of 1900 to 1940. As a proxy to exchange rate volatility employed rolling standard deviation alongside with GARCH conditional variance. The first measure has been derived using monthly percentage changes in the real exchange rate during a period of one year. For the GARCH specification used the log difference of the exchange rate from the period of t to t-1. Interesting thing was that ARCH and GARCH effects were both present in the data, however as mentioned by Baillie and Bollerslev (1989) it is usually a privilege of series with a higher frequency like daily/weekly. Both measures produced similar results, indicating that exchange rate volatility adversely affects trade volumes.

Dell'ariccia (1999) used three proxies for exchange rate variability in the panel data survey covering EU15 (data on Belgium and Luxembourg is combined in one whole observation) and Switzerland during a twenty-year period from 1975. The choice of panel data and instrumental variable techniques is not random. If OLS technique had to be used it will be hard to distinguish whether the results are due to agents' risk aversion or central bank's intervention. All the volatility measures in the paper are replicated using both nominal and real monthly end of period exchange rate data. The following methods are used in constructing the measures: standard deviations of the first difference of the logarithmic exchange rate, the sum of squares of the forward error, the percentage difference between maximum and minimum of the nominal spot rate. Results are indicative of negative effect of exchange rate volatility on trade, and these results are robust after controlling for simultaneity bias.

Sauer and Bohara (2001) have chosen panel data on ninety-one countries during the period of 1973-1993 for their study of exchange rate volatility effects on export. As a proxy for volatility of exchange rate, they used three alternative measures. ARCH (1) process was used to model volatility in logged real effective exchange rate, the choice of specification was justified as in the panel at least 64% had ARCH (1) effects. The other two models are: moving standard error from fitting AR (1) and quadratic trend model of logged real effective exchange rate, where rolling period for both models is 8. It was found that developing countries have much higher real exchange rate uncertainty than the developed ones, and among the less developed ones the highest volatility is found in Latin America and Africa, the lowest in Asian countries. Fixed and random effects models have been used in the analyses. It has been found that the exchange rate volatility effect on exports is not uniform across geographical regions. For Asian, less developed countries, and industrialised countries there was no evidence found on the significance of the relationship. However, for less developed countries of Latin America and Africa an adverse effect has been established.

Even though the nature of the relationship between exchange rate volatility and trade has not been universally established in the literature, most of studies would agree on the significance of such a relationship.

What about trade-unemployment link? Hungerford (1995) proposes a short run theoretical model based on the contract theories concept of worker attachment to the firms. In a model he assumes that equilibrium conditions are determined by domestic and foreign demand supply functions. Shifts from equilibrium will occur in the presence of shocks that include trade tariffs, exchange rate fluctuations, consumers' preference changes and input prices variability. Firms will hire or lay off workers depending on the nature of shocks. The methodology of the paper is based on an endogenous switching probit model to study the incidence of layoffs in US manufacturing industry between 1980 and 1985. He finds that in the short run there is no impact of trade on unemployment. This is viewed by the author as a domestic phenomenon.

Ribeiro et. al (2004) studies the impact of trade liberalisation on employment in Brazil during the period of 1991-1998. Following trade liberalisation at the beginning of 1990s employment in manufacturing industries decreased significantly. Studies have found that trade liberalisation had a net negative impact on aggregate employment growth as it triggered only job destruction. Devaluation of domestic currency had a significant positive impact on net aggregate employment by increasing job creation. However, it is not strong enough to offset the import penetration impact. A 10% increase in current value of import penetration leads to decrease in employment growth of 0.57% whereas a 10% decrease in value of currency implies increase in net employment by only 0.27%.

The literature review on the trade – unemployment link gave rather mixed results. Still based on the empirical findings of the studies we would assume that employment level is negatively affected by free trade and its interaction with other policies (i.e. minimum wages policy Davis (1998)). It was decided to rely on the results of the studies based on the long-run models as due to market rigidities (such as sticky wages, hiring, firing costs) labour markets will need time to adjust.

Concluding, trade is one of the possible channels for explanation on how exchange rate variability can affect the unemployment level. Exchange rates having a significant impact on trade will alter the unemployment level. Due to the unambiguous effect of exchange rate variability on trade we can only assume that the relationship between the variables exists. However, based on the previous studies no conclusion s can be drawn on the direction of the effect.

- *Investment*

Investment decisions are affected by uncertainty. Pindyck and Solimano (1993) estimated the effect of exchange rate variability on investment as a proportion of GDP by using a fixed effects panel regression. Low inflation and high inflation countries are considered during the period of 1960-1990. In a case of low inflation countries (France, Germany, Japan, Netherlands, UK and US), the exchange rate volatility had a significant negative effect on total investment in two out of three specifications, and on private investment in three out of six specifications. For high inflation countries (Latin America and Israel) exchange rate variability had a significant effect on total investment in all three of the specifications illustrated in the paper and significant negative effect on private investment only in one specification out of six possible ones. Aizenman and Marion (1999) find that the volatility of exchange rate is highly negatively correlated with private investment, which is measured as a share of GDP, for 46 countries during the years of 1970-1992. Results of the analysis (sample restricted to 43 countries) suggest that exchange rate volatility has negative significant effect on private investment, and positive significant effect on public investment. Results are not significant for regressions where the dependent variable is total investment.

Goel and Ram (2007) on a sample of 12 OECD countries show that the uncertainty effect is different for different types of investment. Their study uses stock return volatility as a proxy for uncertainty. The degree of irreversibility of investment matters for the significance and magnitude of the impact. Investments with higher irreversibility (fixed capital formation) are more affected by uncertainty than with less (inventory investment). As well private investments are more adversely affected by an increase in volatilities.

Authors conclude that investment types should be differentiated in search of uncertainty effect otherwise conclusions will be washed off. Lensink and Murinde (2007) study gives rise to nonlinear relationship between uncertainty and investments for the UK market. They introduce a threshold level of uncertainty that is critical to investors' behaviour and gives support for the U shape hypothesis. Schmidt and Broll (2009) analyse the impact of exchange rate uncertainty on FDI flows in the US. Their study covers nine US industry FDI outflows to Japan, Germany, UK, Canada, France and Italy during the period of 1984-2004. Adverse effect of exchange rate uncertainty on FDI outflows was estimated using a standard deviation based measure of volatility. When using alternative measure of volatility, the estimated effect is still negative for manufacturing sectors but positive for non-manufacturing ones. Furthermore, the empirical result of Wang et. al. (2011) using the Dow Jones Index companies is evident that they will decrease investment under increased uncertainty. However, where there is a lower exchange rate and interest exposure ,companies tend to draw their finances from overseas entities by debt issuance in order to finance their investment projects.

Kandilov and Leblebicioglu (2011) estimate the effect of exchange rate volatility on plant-level investment for Colombia during the period of 1981-1987. They find that using GARCH and standard deviation based measures of exchange rate volatility there is a highly significant negative relationship between the variables of interest. Using a GARCH based measure, their research revealed that a 1% increase in conditional volatility reduces investment by 0. 39%. And a one standard deviation decrease in volatility induces an increase in investment level by 12%. Whereas using alternative measure of volatility it was estimated that 1% increase in volatility leads to 0.18% decline in investment levels.

Escaleras and Kottaridi (2014) study the effect of macroeconomic uncertainty on private investment using a panel of 37 developing countries during 1970-2000. Macroeconomic uncertainty in the research is presented by exchange rate and inflation volatilities. They find strong evidence of an adverse effect of exchange rate volatility on private investment, whereas evidence for inflation volatility is much weaker. Similar results are obtained for non-linearity where quadratic forms of uncertainty are assumed.

2.1.3 Summary of theoretical and empirical findings on the indirect links.

Both theoretical and empirical reviews have been evident of uncertainty having impact on a firm's fundamental decisions. Theoretical findings assume that uncertainty creates an additional component to the cost function. This, then, translates into pricing strategy, and distorts optimal price and output level. Empirical findings suggest that it affects a firm's cash flows and its value. This in turn affects its borrowing, investment and trade activities. All of these leads to alteration in optimal capital labour ratio, thus changing unemployment level.

However, neither theoretical nor empirical studies reach consensus on the nature of this amendment to the unemployment level. The reason for this lies in theoretical assumptions behind the models considered. So, direction of the effect will depend on source of uncertainty, risk nature of the shareholders, market conditions, elasticity of demand, market rigidities and nature of a firm's operations.

2.2 Macroeconomic volatilities effect on unemployment.

2.2.1 Theoretical foundations: investment theory approach

Dixit (1989a) draws parallels between decision in financial market to invest and in labour markets to hire. Before any decision is made he assumes in both cases analysis is made on the basis of option valuation. Similarly to set up costs in investment - hiring a worker implies fixed and variable costs. Sunk costs are associated with recruitment, training and redundancy, and wage is a variable cost whereas return to investment is related to individual's productivity. Belke and Setzer (2003) take Dixit's (1989a) idea further and develop a model explaining exchange rate variability impact on job creation. They introduce a 3-period fixed model where an export-orientated firm decides whether to create a job. Once a working place is created, a worker will be recruited for the consecutive period(s) and the output will be realised. There is no firing of a worker before the date of contract termination. We will follow Belke and Setzer(2003), Belke and Kaas (2004), and Belke (2005) model here. However, for comfort we use different notation from the original. It is assumed that firms are risk-neutral and therefore bear all the exchange rate risk. Now we can derive the expected profits if a firm decides to enter a project at the first or second period, starting with the earlier case. Expected return to project in any of the periods 2 and 3 is the difference between price, p^*, and variable costs, w. Expected net profit for project is the sum of expected returns on project in both periods adjusted for firms bargaining position, 1-β, and sunk costs:

$E(P_1) = 2\pi(1-\beta) - c_s, where\ \pi_i = \rho_i^* - w_i\ and\ i = 2,3.$

If firm takes the option to wait and enters project only in the second stage then there should be some benchmark value of the exchange rate that should be fulfilled. This value can be found at a point where firm will be indifferent between undertaking the project in period 2 or not, i.e. firm's expected profits will be zero:

$$E(P_c) = (\pi + e_b)(1-\beta) - c_s = 0,\ then\ e_b = \frac{c_s}{1-\beta} - \pi.$$

If actual volatility in period 2 is the benchmark level of volatility only then a job will be created potentially adding $((\pi + e_2)(1-\beta) - c_s)$ value to a firm and a one period wage pay to employee. If expectations are not realised then a job is not created and nothing is gained.

Expected unconditional return to the project is based on sensitivity analysis and includes the probabilities of realisation of expected exchange rate volatility in period 2, σ_2:

$$E(P_2) = \frac{(1-\beta)(\sigma_2 - e_b)^2}{4\sigma_2}$$

Firms will be more reluctant to hire and prefer to wait until more information is gathered on exchange rate behaviour if expected net profits in period 2 will be larger in contrast to the first period. That is where $E(P_2) > E(P_1)$. Thus, estimated value of a decision to enter is directly related to volatility of exchange rate implying that with high volatility in place firms are better off deterring from actions in period one. Firms will be indifferent in which period to enter at the point where expected profits from two decisions are the same:

$$\sigma_2^b = 3\pi - \frac{c_s}{1-\beta} + 2\sqrt{\pi(2\pi - \frac{c_s}{1-\beta})}$$

If the realised volatility of the exchange rate in period 2 is greater than the threshold value estimated above then firms will be reluctant to hire. From the threshold value we can see how exchange rate volatility theoretically interacts with other micro indicators. The negative effect of volatility on job creation will be amplified in cases where employees are dominant in bargaining power, high hiring and redundancy costs, and high reservation wages. Even though wages are not directly present in the equation, recall from assumptions that profit in any period is the change in prices and wages:

$$\sigma_2^b = 3(p-w) - \frac{c_s}{1-\beta} + 2\sqrt{(p-w)(2(p-w) - \frac{c_s}{1-\beta})}$$

Dominant employee bargaining power is usually associated with the presence of strong trade unions power. Whereas high wages are created on the basis of high unemployment benefits and minimum wages, high sunk costs arise in places with strict employment protection legislation policies. We need to underline one of the major findings of the Belke and Setzer (2003) study is that firms in their decisions will be sensitive to short-term volatilities, i.e. period 2 volatility. This is very important as short-term volatility can induce long-term fallbacks in the system.

OECD countries being the focus of a study mostly employs strict EPL policies, unemployment benefits, some having wages set in collective bargaining by unions and some by the means of minimum wages.

However OECD (2010c) research showed that in OECD countries characterised by tough employment controls during crises companies, facing a need for more flexible labour, increased their labour shares in part-time employed. This structure allows being more flexible and efficient in cost cutting during periods of adjustment to economic disturbances. So the assumption of Belke and Setzer (2003) labour force being fixed for the whole period is very crude.

Later studies of Belke and Kaas (2004) extended their initial model by relaxing the assumption of fixed labour force and redundancy barriers. Now firms sign binding agreements with employees only for one period. Under new model assumptions the expected return if firm enters in period one is given by the function:

$$E(P_1) = \begin{cases} 2\pi(1-\beta)-c_s \text{ , if } \sigma_2<\pi \\ [(1-\beta)\pi-c_s]+\left[\frac{(\sigma_2-\pi)}{2\sigma_2}\right]\times 0+\left[\frac{(\sigma_2+\pi)}{2\sigma_2}\right](1-\beta)\left[\pi+\left[\frac{(\sigma_2-\pi)}{2}\right]\right] \text{,if } \sigma_2\geq\pi \end{cases}$$

If volatility of exchange rate in the second period is within the expectations, i.e. less than the profits from period one, then the firm is expected to keep its operations running into the third period. In this case expected value that a firm could gain during three periods of business is the same as in the general case. If volatility changes in period 2 are not plausible then it becomes unprofitable for both parties to keep the contract. However, the expected value of a firm in this case changes from the extended model. This is due to the fact that now firms can choose whether to keep the labour force, or to terminate the contract. Therefore, the expected value of a firm will be the sum of potential profits from period 2 and the weighted average of two options.

In the case of a second strategy, where a firm decides to wait and see what happens with the volatility, expected firm's profits are given by:

$$E(P_2) = \begin{cases} \max(0,\pi(1\text{-}\beta)\text{-}c_s)\,, & \text{if } \sigma_2 < \left|\pi - \dfrac{c_s}{1-\beta}\right| \\ (1\text{-}\beta)\left[\dfrac{(\sigma_2+\pi\text{-}\frac{c_s}{1-\beta})}{2\sigma_2}\right]\left[\pi + \left[\dfrac{\left(\sigma_2\text{-}\pi\text{-}\frac{c_s}{1-\beta}\right)}{2}\right]\right], & \text{if } \sigma_2 \geq \left|\pi - \dfrac{c_s}{1-\beta}\right| \end{cases}$$

If volatility does not overweight profits adjusted to a share of fixed costs then firms are willing to hire if expected profits are positive. However, if volatility is greater in magnitude than the profits deducted by a share of fixed costs, then expected profits would be largely subject to volatility.

So, we end up with three possible intervals of values that volatility can take in this case:

$\boldsymbol{\sigma_2 < \left|\pi - \frac{c_s}{1-\beta}\right|}$: Here firms will choose to hire an employee for two contractual periods (2 and 3). This result is justified by comparison of expected payoff values from available options. In this case firm will be willing to create job and will have no incentive to destroy it in the next period.

$E(P_1) = 2\pi(1\text{-}\beta)\text{-}c_s$, whereas $E(P_2) = \max(0,\pi(1\text{-}\beta) - c_s)$

$2\pi(1\text{-}\beta)\text{-}c_s > \pi(1\text{-}\beta) - c_s > 0 \;\therefore\; E(P_1) > E(P_2).$

$\left|\boldsymbol{\pi}-\frac{c_s}{1-\beta}\right|<\boldsymbol{\sigma_2}<\boldsymbol{\pi}$**:** here a job is always created in period one by firms, however it is not clear whether it will be kept for the third period.

$$E(P_1) > E(P_2)$$

$$2\pi(1\text{-}\beta) - c_s > (1\text{-}\beta)\left[\frac{(\sigma_2 + \pi - \frac{c_s}{1-\beta})^2}{4\sigma_2}\right]$$

Equation holds at endpoints of the interval as well $\sigma_2 < \left|\pi - \frac{c_s}{1-\beta}\right|$ is concave. Therefore, it should hold for the whole interval. So here firms will keep their labour force for the two consequent periods after recruitment.

$\boldsymbol{\sigma_2} > \boldsymbol{\pi}$**:** Here companies are willing to hire in period one however there is a probability of $\frac{\sigma_2-\pi}{2\sigma_2}$ that job destruction takes place after period 2.

Summing up, Belke and Kaas (2004) show that in the presence of minimal fixed costs, jobs are always created independent of exchange rate volatility levels. However, exchange rate volatility has impact on job destruction levels by inducing probability of $\frac{\sigma_2-\pi}{2\sigma_2}$ of employees becoming redundant.

2.2.2 Empirical results of macroeconomic variables effect on unemployment.

Belke and Gross (2001) estimate the impact of exchange rate volatility on employment, unemployment and investment levels during the period of 1973-1996 for 11 EU countries (Belgium, Denmark, France, Germany (West Germany), Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and United Kingdom). Results of baseline regressions, using OLS technique and for unemployment rate being a dependent variable, are in line with expectations for all countries. Coefficients of the level of exchange rate variability are significant at least at the 10% significance level for all countries. However, the same technique applied to employment rate shows different results. In case of Ireland a positive sign is obtained instead of the expected one and in case of Denmark significance of the result is lost. Authors interpret unforeseen result for Ireland by the fact that its national currency was fixed to British pound until 1979. An attempt to correct the sample by limiting it to the floating period of 1980-1993 came successful, and the result became insignificant. Robustness tests were performed using OLS to check the validity of the results. Regressions are limited to employment being dependent variable only and control variables are extended to include intra-ERM exchange rate volatility, interest rate spread, GDP growth, and change in short-term interest rate. Intra-ERM exchange rate volatility appeared to be statically significant (at least 10% significance level) for all countries including Ireland and Denmark. In line with previous results negative impact of exchange rate volatility on employment is estimated for all countries except Italy. Results for the inclusion of further control variables are less universal but are still strong for some countries in accordance with specifications. Once SUR technique is used, exchange rate volatility impact on unemployment becomes highly significant (1% significance level) with expected sign direction in all cases except for the unemployment rate in Italy. Employment and investment regressions under SUR estimation reveal more significant results as well. Significance of the latter is evident for investment being one of the pass through channels between exchange rate volatility and unemployment. Further studies of Belke and Gross (2002) extend the sample across the Atlantic to include US data in addition to “Euroland” countries. “Euroland “countries comprise Austria, Belgium, France, Germany (West Germany), Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and Finland. Data range for the analysis varied slightly depending on the measures of volatility used, but in general it gives picture for the period starting with 1980 for the first observation at the latest and ending with year 1999. Baseline specifications show that impact of exchange rate variability has long-term effects on employment in Euroland countries but not for the US. In Europe, an increase of one percentage point in variability of exchange rate reduces employment rate by 1.01% in first year, 0.93% in the second year, and further 1.44% in the third year. Results are striking especially if we take into account their high statistical significance (1% significance level.). Analogous, specifications for the US gave no similar result, as exchange rate variability is not significant. For unemployment rate results differ, as in the case of US reduction in exchange rate variability by one percentage point reduces employment in the first year by 0.57% (result is significant at 1% level). European unemployment is more long-term sensitive to exchange rate variability where a one percentage point increase in exchange rate variability is associated with only a 0.47% rise in unemployment level in the first year (10% significance level) and is followed by a further 0.9% in the third year (1% significance level). The difference across Euroland and the US can be explained by the difference in labour market policies and rigidities (i.e. recruitment and redundancy costs levels). The study of Belke and Setzer (2003) uses a panel of Visegrad countries during the years to see whether the established exchange rate volatility – labour market performance relationship holds. Visegrad countries include Czech Republic, Hungary, Poland and the Slovak Republic. Data covers a 10-year period of monthly observations during the years 1991-2001. The regressions account for business cycle variations and are estimated using either feasible GLS or SUR techniques. Exchange rate volatility has a significant impact on unemployment in a majority of regressions. Fixed effects estimation reveals that short-term volatility of exchange rate has an impact on the long-run values of unemployment rate with economies of Poland and the Slovak Republic being mostly affected. Belke and Kaas (2004) expand previous research implications further eastward and add to the sample of four Visegrad countries of Belke and Setzer (2003), six Central and Eastern European countries. These are Bulgaria, Estonia, Latvia, Lithuania, Romania, and Slovenia. Baseline results suggest that exchange rate variability enters equations with a two-year lag, indicating that labour market rigidities (i.e. labour contracts) slow the adjustment process. Exchange rate variability estimated coefficients exhibit expected sign in all regressions and yield significant results in a majority of equations. According to the specification, Baltic States labour markets are the most sensitive to exchange rate variability. CEEC countries are a too heterogeneous group to have a common coefficient for exchange rate volatility, and researchers use a more generalised specification. Heterogeneity among countries can arise due to differences among labour markets or historical exchange rate volatility. Under new specification it was found that exchange rate volatility has impact on labour market with one lag, except for Slovenia. The Slovenian labour market shows no signs of exposure to exchange rate variability.

The study of Jung (1996) examines if there is a causal relationship between exchange rate volatility and unemployment using Granger causality tests. West Germany case is used for the period of 1977 to 1995 to avoid potential structural breaks associated with Germany reunification. Results of Belke and Gross (1996) were not confirmed and inverse causal relationship was found between exchange rate volatility and unemployment. Volatility was derived using daily standard deviation of exchange rate. Unexpected results can be explained by the misspecification of regression equation, as relationship is more complex involving a number of fundamentals.

Buscher and Mueller (1999) investigate models proposed by Belke and Gross (1996) and Jung (1996) and extend them in search of a universal conclusion. Drawing on potential limitations of previous studies they use a number of volatility measures on a monthly and annual frequency data. Volatility of German Deutsche Mark is at the heart of the analysis with its bilateral weights against five representative currency groups – EU14, EMS, Representative countries, Peripheral countries and Core countries. Evidence in favour of positive relationship between volatility of exchange rate and unemployment rate was found, using annual and monthly data from 1973-1997. However, using annual data yields specifications with lesser magnitude of volatility on labour market performance.

Chang et. al. (2007) extended the research area in two ways. First, list of countries studied includes Singapore, Taiwan and South Korea. This is contrary to developed economies that have been previously employed by researchers. Second, on a technical part of the analysis they use bivariate GARCH-in-Mean structure to model unemployment exchange rate volatility relationship. It is found that the lagged exchange rate has no impact on the unemployment rate in all three countries under consideration. The positive impact of exchange rate uncertainty on the unemployment rate has been found for all three countries. However, for the Singapore economy it is the weakest of all. Chang and Shen (2011) have come back to the question of exchange rate volatility and unemployment interrelationships for the three Asian economies. GARCH-in-mean structure with GARCH (1,1) has been used again, but this time analysis is relied heavily on Generalised Impulse Response Functions. It has been shown that exchange rate uncertainty shock is persistent for the Taiwan economy, quickly dies out in the case of South Korea and has powerful initial impact on Singaporean economy that decays with time.

The study of Demir (2010) examines exchange rate volatility effects on employment growth in Turkey. The novelty of the research is in two details. First of all, the country of interest is Turkey that has not been considered before for this problem. Secondly, employment growth regression is based on Cobb-Douglas production function, as this study looks at question of employment from a microeconomics perspective. Findings suggest that exchange rate volatility has a negative impact on employment growth in the manufacturing sector for the years 1983-2005. Furthermore at firm level it was found that a rise in export share operations and leverage ratios increases the magnitude of adverse effects associated.

Feldmann (2011) discusses exchange rate volatility effect on unemployment for 17 industrial countries. GARCH (1,1) volatility measure of exchange rate is being used. Estimators based on fixed effects or random effects are suggestive of volatility having positive effect on unemployment.

Feldmann (2012) studies inflation volatility effect on unemployment of 20 industrial countries. This is the front page of the research on the area as it is the first one afield. Inflation volatility has been approximated by rolling standard deviation by the means of two distinct short-run and long-run measures that are used simultaneously in the regression analysis. Results indicate that inflation volatility has small, but persistent effect on the unemployment rates.

2.2.3 Summary of previous findings on macroeconomic volatility and unemployment level.

In general, empirical findings of previous researches are evident of macroeconomic volatilities increasing unemployment level. Belke and Setzer (2003), pioneers in theoretical framework in the field, explain lower unemployment levels by exchange rate volatility dumping job creation levels. All of the previous studies agree on the small magnitude of the effect.

2.3 Hypothesis.

Based on previous empirical results it is expected of macroeconomic volatility to increase unemployment level. Regarding other labour market performance indicators, we built the hypothesis based on theoretical findings of Belke and Setzer (2003). They state that volatility decreases job creation rates. Fewer jobs to offer at the labour market are to be associated with longer unemployment spells, higher number of discouraged workers, and lower labour force participation rates.

Chapter 3. Data Construction and Sources.

Labour market performance model has been built following the intuition of Nickel (1998) and Nickel and Layard (1999). In cases of group specific labour market performance composition suggestions of Bassanini and Duval (2006b) additional variable construction has been adapted for the current research. While almost all of the dependent and control variables' construction and sources are described in this chapter, volatility measures derivations are discussed in great detail in chapters 4 to 6 of the thesis. Not all of the variables as initially planned have been included in the analysis. Main reasons behind the decision are low data availability rates and change of variables definitions.

3.1 Dependent variables: labour market performance indicators

- *Employment Rate measures*

We included a number of variables to measure labour market performance. One of the orthodox ways to measure labour market performance is to control directly for the employment situation. Here we used aggregate employment, total and civilian unemployment indicators. *Aggregate employment data* has been obtained from OECD Labour Force Statistics (LFS) by sex and age where it is calculated as the employment to population ratio. According to the LFS definition employed persons are those who work at least one hour per week, disregarding whether they paid for it or not (i.e. this includes unpaid family workers).

Data availability for employment rate is poor. It does not cover the whole period considered here of 1985 onwards. Extent of this can be seen from Table 3-1, where summary statistics for the variables is present. There are only 339 observations available for employment rate. One can compare it to unemployment rate series, which data sample has 572 data points. Average employment rate among the series is 58.14%. Observing employment rate country plots can give more detail (Appendix A2.2). Highest employment rate is found in Norway (71.9%), it is of no surprise, as this is the country with highest average employment rate. Country with the lowest rate of employment is Italy. It has both – minimum employment rate observation and lowest employment rate on average. Looking back at the graphs, France is the country with lowest variability in employment rate and New Zealand with the highest. But these results are very biased as they are subject to data points available. France has only eleven points representing the more stable period in labour markets of 2000s. New Zealand's sample number of observations is 28. Hopefully, unemployment rate series would bring more clarity to the labour market description questions as they have more observations.

In relation to the unemployment data, LFS defines unemployed persons as those who are currently unemployed but economically active. The importance of the above is that discouraged workers are not included in the series as unemployed as they are classified as economically inactive. Thus care should be taken in discussion of the results of institutional policies that affect a labour market performance to avoid misleading interpretation. For example, a decrease in both of the rates of taxation and unemployment benefits increases incentives of job search for discouraged workers. Thus, increasing numbers of the economically active in the short term. This will lead to an increase in the unemployment rate when institutional policies change, at the same time this link could have been erroneously interpreted as a negative relation between the variables. *Aggregate unemployment data* were taken from OECD LFS by sex and age and is measured as unemployed to labour force ratio in percentage units. *Civilian Unemployment rate* was obtained from the OECD Annual Labour Force Statistics, where it is defined as the rate of unemployment as a share of civilian labour force for those of working age, 15-64 years. Civilian Labour Force is a better indicator, as it does not include armed forces. Army personnel are generally less sensitive to the disturbances in institutional policies and macroeconomic indicators.

Contrary to employment rate series, there is a better data availability for unemployment rate series for all countries. On average unemployment rate for 20 OECD countries is at 7.4% (Table 3-1). Looking at the unemployment rate series plots (Appendix A2.1), it can be seen that this mean value is not true for all the countries. For economies of Australia, Canada, Denmark, Germany, New Zealand, Portugal, Sweden, UK and US average unemployment rate values lie within the range of 6.14%-8.4%. Austria, Japan, Netherlands, Norway and Switzerland economies are characterised by low unemployment rates. Minimum value in the dataset of 0.5% of unemployment rate belongs to Switzerland, country with smallest average unemployment rate at 2.84% among twenty countries considered here. However, lowest standard deviation value attributes to Austria. So, according to standard deviation, there is less variability in unemployment rate of Austria among the twenty OECD countries.

Belgium, Finland, France, Ireland, Italy and Spain are characterised by higher unemployment rate on average. Unemployment rate plots (Appendix A2.1) would help to see whether this is a consequence of outliers or is it genuinely higher unemployment rates. For Belgium, France and Italy unemployment rates always varied around 10% mark. For Spain, Ireland and Finland unemployment rates picture is different, its much more volatile. Spain is the country with highest average unemployment rate of 17.38%. Not a surprise, maximum value of unemployment rate of 26.2% belongs to Spain as well as this is the country with highest volatility of unemployment. Unemployment rate there has always been high during the period except in 2000s when it was gradually reduced on average by 10%. However, after the crisis of 2008 control over unemployment rates was lost and rates shoot of. Second most volatile unemployment rates are in Ireland. This country is characterised by high unemployment rates on average at 10.8% during the period. Similar to Spain, country experienced reduced rates in 2000s but after the financial crisis unemployment rates increased. Contrary to Spain, unemployment rates in Ireland have been reduced after 2012. Finland's economy experienced high unemployment rates and volatility. However, once they were reduced in 2000s it managed to control them even through the financial crisis.

But, using LFS data series for panel data is not always beneficial for the research where international comparison is at the centre of the analysis. Disadvantage of the above described LFS data variables is difference in timing of data collection and its publishing across countries. The best way to treat this problem is to use the seasonally adjusted *Harmonised Unemployment Rates* available from OECD employment database, LFS – MEI (Main Economic Indicators). Unemployment rate is given as a percentage share of unemployed to civilian labour force. Harmonised unemployment rates are calculated by Eurostat for EU member countries and Norway, Canada, US, Australia, Japan, New Zealand and Switzerland. The OECD uses data from the National Statistics Offices (NSO). Definitions of unemployment series follow ILO guidance with one exception - surveys covered only include household members and do not take into account those living in institutions.

Appendix A2.1 represents comparative graph of both of the series – unemployment rate (ALFS) and harmonised unemployment rate. Initial observation is that not for all countries there is difference between the two indicators. For Australia, Canada, Japan and US, series have similar number of observation and very close statistical properties. Contrary to that, number of observations available for Switzerland changes dramatically once ALFS derived indicator is changed to the harmonised unemployment rate. Loss of observations is equal to twenty-five points out of twenty-nine. Observations loss for other countries is comparatively less (e.g. Austria loses seven observations and Germany six). As well, from the graph it can be seen that major divergence of the series' plots is attributed to the period of 1985 to 2000. After the 2000s the differences between the series are minimal and series converge to one value. This convergence can be explained by development of better data collection skills. Thus, with time there is higher quality data available irrespective of which indicator is being used.

Another point worth to mention is that variability of harmonised unemployment rate series is smaller than in the case of its alternative. However, it could be a consequence of harmonised unemployment rate series covering less data points that lie at the beginning of a sample. And, from data plots, it can be seen that unemployment rates towards 1985 end were more volatile.

- *Labour force participation rate*

Another way to control for labour market performance is to look at the changes in the Labour Force participation rate (LFPR). It provides an opportunity to see how macroeconomic variables or institutional policies stimulate labour supply and their effect on voluntary unemployment. Low participation rates reduce labour inputs in the economy, thus reducing overall economy output. Meanwhile the unemployment rate indicator may not signal any critical disturbances in the labour market. However, dynamics of LFPR variable in this case can be evidence of continuous labour force withdrawal. For the robustness checks, using labour force participation rate in conjunction with unemployment rate results, it will be a good idea not to miss any labour force hysteresis effects. Data series were obtained from OECD LFS by sex and age, where it was calculated as a percentage ratio of labour force to population.

Activity rates are another alternative to LFPR variable. It is found as a ratio of active population that is defined as a sum of numbers of employed and unemployed to workforce that is defined as a sum of active and inactive population. This variable contains in the relatively new dataset provided by OECD called Short-term Labour Market Statistics. It provides data similar to ALFS based on 34 countries. Activity Rates variable has been used where possible as it is also available for different labour market participating groups according to their age and sex. But in cases where the number of observations available is significantly lower or missing, LFPR variable has been used instead (e.g. for older and retiring population groups statistics).

Activity rates series have plotted in Appendix A2.3.

- *Duration of unemployment*

Unemployment duration provides a good indicator of how long unemployment spells are and how quickly do market participants exit unemployment. It is a particularly useful instrument in examining active and passive labour market policies and in drawing up consequences of economic shocks. For the research OECD the duration of unemployment variable has been used. This variable is subdivided into 5 groups according to the unemployment duration period- less than one month, 1-3months, 3-6 months, 6-12 months and more than 12 months. For the analysis variables with duration of unemployment up to 6 months have been accumulated to get a variable of unemployment duration less than 6 months. Please note that unemployment variable sums up across all of the periods up to 2 years to 100%. As variables are complementary to 100%, then effect on those in unemployment for less than 6 months is opposite on those who are in employment for more than 6 months (but less than 2 years). Primary data was obtained from OECD ALFS dataset and is expressed as a percentage of unemployed. Series are plotted in Appendix A2.5.

- *Structural unemployment*

Non-accelerating inflation rate unemployment (NAIRU) variable was chosen to control for structural unemployment dynamics. Structural unemployment measure is crucial in assessing success of Active Labour Market Policies as they intend to reduce deterioration of the skills of unemployed and assist them with retraining. Total factor productivity shocks aftermath can be well studied by its effect on structural unemployment as well. NAIRU variable is available from OECD Economic Outlook database.

Data availability for the NAIRU indicator is best as it has 589 observations (Table 3-1). Still, standard deviation of the series is much less than for the other unemployment indicators. Overall graphs in Appendix A2.4 look more flat with inflation adjustment than without. All of this is reflected, in the other data statistics, i.e. lower mean value and smaller interval between minimum and maximum values. Lowest minimum value of 0.99% belongs to Switzerland and highest value of 21.5% to Spain.

- *Discouraged workers.*

The number of discouraged workers indicator is firmly linked to labour force participation rates. While LFPR rates of workforce give us dynamics in numbers of active population, some of that population goes into employment but some of that population withdraws from the job search process. So to understand the case of crowding out effect in activity rates, one should have a look at discouraged workers indicator. It provides the number of people who involuntary left the labour market due to the jobs mismatch and their belief that employers in the labour market no longer require their skills. This variable and its importance have been first highlighted in OECD (1995) and since then have been regularly included into statistics supplements. Now it is available from the Labour Force Statistics of OECD. Here, indicator used compromises number of discouraged workers as a share of extended labour force that includes both active workforce and discouraged workers. Series have been plotted in Appendix A2.6

3.2 Control variables: policy and institutional indicators

- *Tax wedge.*

Theoretical foundations. The tax wedge is a gap between the cost of labour to employer and actual wage income of the employee. Tax wedges decrease purchasing power of employees, increase expected wages thus reducing labour force participation rates. This effect deepens in cases where there are high unemployment benefits present because they provide direct exit from employment and tend to prolong unemployment spells. Taxation will decrease the purchasing power of the employee and increase the reservation wages of the market participants. This will reduce labour supply, create inefficient job search and matching process. All of the above attributes to unemployment growth.

Progressive and uniform taxes have different effect on unemployment. In the case of progressive taxation higher marginal utility of labour decreases with higher productivity, thus there will be diminishing returns for employees per extra hour of work taken. From the point of view of efficiency wages theory firms could increase wage levels so to increase productivity of employees. However, the desired effect will not be reached, as associated increase in marginal cost of labour will not be matched by the same rise in wage pay. The competitive models mechanisms will not apply any longer as taxation drives a wedge between relative prices perceived by the market participants. Therefore, wages will have to go down as productivity will decrease and companies will have to employ more labour force in order to match the change in productivity of employees. This will increase employment in the economy but decrease labour costs and purchasing power of wages. (Cahuc and Zylberberg (2004), p.764).

In case of uniform taxation employees' marginal utility of labour will be increasing uniformly with higher productivity, as there will be the same level of tax at all levels of productivity. Labour supply will still decrease with the tax incidence having negative effect on income, i.e. purchasing power of wages will decrease, and associated substitution effect will be still negative. Therefore, in contrast to the previous case employees will be motivated to take extra hours of work in order to compensate for the income loss due to tax incidence. Firms will not be willing to increase labour demand due to productivity gains of the existing labour force. However, they will increase wages to match the increase in productivity. Summing up the changes in labour supply schedule and increase in productivity of labour, steady state of the economy will appear at a lower employment level and higher wages, than the initial one (Salanie, 2003).

The effect of taxation on unemployment is ambiguous and it depends mostly on the balance of income and substitution effects of taxation. Increase in taxation can generate income effect and increase labour supply, as households' income will decrease. However, if taxes are great enough then they will contribute to large substitution effect that would decrease labour supply, as opportunity cost of options will go down. Taxation effects on the welfare of society including labour markets as one of the indicators cannot be considered in isolation of passive labour market policies, i.e. benefit system, as they are closely related by the dynamics of the economy and could imply indirect effects.

Variable construction and sources.

"Taxing Wedge from Taxing Wages Database". Here we combined two sets of OECD data. First set is historical data series on total tax wedge inclusive of employer payroll taxes that goes back to 1977 (varies largely depending on country) but stops at 2004. It gives data for average tax rate for a married couple with one of the partners at work and

two kids. Second set used is a new dataset that goes back to 2000 and has all the most recent data observations. Definition of a family type for the new series is the same.

The primary difference among definitions lies in the definition of the average worker. Historical data series assume that the average worker is a full-time manual worker in manufacturing sector, whereas an updated version recognises average wages as a combination of full-time manual, non-manual workers working in a range of sectors in the industry. Such a substantial change in definition has driven a dramatic difference across series of gross wage earnings. According to OECD (2005), the new definition implied change for the year 2004 observations of more than 20% for Austria, France, Portugal and United Kingdom, 15%-20% for Germany and Sweden, more than 15% for US, and more than 5% for Canada and New Zealand.

Assuming that more recent data show the overall trend for the workers in the industry, we will splice up more recent dataset with the original data set from the year 2004. Splicing up will be done by normalising series of a more recent dataset by the difference value of the 2004 for both data sets.

Following Bassanini and Duval (2006 b) methodology additional marginal tax rates have been derived for the group specific labour market regressions. First, *"relative marginal tax rate on second earners"* should be considered. This variable is effectively a tax wedge for second earners. Assuming a couple with two kids and first earner receiving average wage, the main concern is how motivated is second earner to go into full time employment. Comparing net income between two situations when second earner receives average wage or is unemployed relative to appropriate difference in gross income between the two scenarios. Similarly, *"relative marginal tax rate for an individual to go from part-time employment into full-time"* has been estimated. Assume single earner without children who earns average wage in full-time and only 67% of average wage in part-time work. Now, the marginal tax rate will be calculated as the net income differential between the two scenarios (full-time versus part-time employment) as a proportion to net income of part-time employment. All the data for variables construction is taken from Tax, Benefits and Wages: OECD Main Tax Benefit Indicators Database.

- *Employment protection legislation.*

Theoretical foundations. Employment Protection Legislation creates rigidities in company's labour turnover mechanism by adding firing costs to its profit optimisation problems. With the introduction of firing costs firms cannot adjust its labour force instantaneously during demand or supply shocks to the economy. Firm's decision to keep or fire an employee will be directed by the reservation productivity. Reservation productivity is a productivity level of the employee at which employer is indifferent to keeping or firing the employee (Cahuc and Zylberberg (2004)). It is where profit from keeping an employee, determined by employee's productivity, is the same as profit from making him redundant, determined by profit of having workplace vacant inclusive of firing costs deductions. If employee's individual productivity is less than the reservation one he will be fired. Similarly if it overwhelms reservation productivity then he keeps the job. Therefore, according to theory, a rise in firing costs will decrease reservation productivity, thus lowering job destruction rate. This in turn may smooth the effect of economy fluctuations on labour market activity by restraining the unemployment rate from overshooting in the short-run. In long-run lowering job destruction rates will increase current employees' confidence in the wage bargaining process so they would demand higher wages. Upward pressure on wages should result in higher unemployment. However, firms tied up by EPL policies will suffer temporary losses until they will be able to decrease a firm's employment level to the competitive one through pausing recruitment and by voluntary quits.

An increase in labour turnover costs will decrease the exit from employment, consequently reducing labour demand. Meanwhile it will increase hiring costs as companies would induce probability of firing an individual and all subsequent costs in profits optimisation analysis. A rise in hiring costs allied with a decrease in labour demand would lower job creation rates in the economy. Lower job creation rates and job destruction rates would simply mean lower labour market flows. This implies prolonged unemployment spells, especially for the new entrants to the market. Long durations of unemployment would decrease reservation wages of the market participants. A downward push on wages will stimulate an increase in voluntary unemployment, and reduce the costs to firm's profits. This should be an incentive for firms to recruit, thus in long term this could increase employment rate depending on the replacement cost of insider to outsider. However it is necessary to keep in mind that long unemployment spells have negative effects on the human capital, i.e. quite often the level of skills of those searching for jobs decreases with the search time.

Net effect of EPL policies on unemployment rate would depend on the difference in the rates of job destruction and job creation. The economy aggregate rates of jobs turnover will be dictated by labour demand conditions and will depend on the nature of downturns, i.e. whether they are aggregate or idiosyncratic to a particular sector.

There will be a difference of the EPL policy effects on unemployment among different labour market groups – insiders and outsiders. As we have seen above, for those in employment, stricter EPL will increase the unemployment rate in the long-run and stimulate a rise in wages. For those willing to enter the labour market it will increase employment in the long-run at the cost of decreasing wages, if the required conditions are met.

Variable construction and sources.

In measuring EPL strictness we use OECD synthetic indicator relative to overall labour force, regular contractors and temporary ones. EPL indicator for employees on temporary contracts is a weighted sum of indicator on types of work, restriction on number of renewals, maximum cumulated duration of successive work. EPL indicator for employees on regular contracts is a weighted sum of indicators on employee dismissal - notification procedures, delay involved before notice can start, length of notice at periods of 9 months, 4 years and 20 years of tenure, severance pay levels at 9 months, 4 years and 20 years of tenure, definition of justified or unfair dismissal, trial period length, compensation for unfair dismissal and possibility of reinstatement after unfair dismissal. EPL overall employment indicator is an unweighted average of the above sub indicators for regular and temporary contracts. The motivation to choose the earlier version among OECD indicators comes from the highest range of data availability. Data Source: OECD Stat.Extracts.

- *Minimum wage.*

Theoretical foundations. Effect of minimum wages on unemployment will vary according to the value of minimum wages imposed in relation to current market equilibrium wages. If the minimum wage is above the market-clearing wage then theoretically it will give rise to classic unemployment. Higher wages will push the supply of labour and labour force participation rates upwards, as it will cumulate population with higher reservation wages who will enter the market directly as unemployed. The more elastic is the labour demand - the wider is the unemployment gap created by the imposition of minimum wage. However, if minimum wage is lower than the reservation wage, then it could have a positive impact on employment and even improve labour market efficiency. This is the case when monopsony power or any other models where the settled wage is below the competitive wage.

According to efficiency wages theory higher wages should imply higher productivity. Higher standards of productivity required could push the labour force into additional training and education, and in short run this could decrease unemployment partially. In the long-term this can cause an increase in aggregate labour productivity, as payoffs for acquiring additional education levels increase. Higher productivity implies higher revenue and profit margins for the firms so this will give them a motive to increase labour factor within the firm. Higher demand for labour could imply clearing the classical unemployment created by the minimum wage.

Setting floor for wages, demanding higher rates of productivity could imply high impact differentials of the policy among different groups. Higher positive impact of the policy would be expected on low skilled labour and less on the high skilled labour. Skills level is usually attached to educational attainment level. However, firms view skills level signal as a combination of work experience and education level. So even if new entrants to the market could have a high level of education they still could be viewed as disadvantaged, due to a lack of work experience. New entrants to the market (usually age group of 16-24 graduates) could be affected by the minimum wage more than the other groups.

Variable construction and sources.

Only seventeen out of twenty countries of interest that we study have minimum wage legislation in place. However those countries where minimum wages regulation was not passed (Austria, Denmark, Finland, Italy, Germany, Norway, Sweden, and Switzerland) balance with a help of union bargaining power in the wage setting process.

The OECD indicator “minimum relative to average wages of full-time workers” was used to measure the minimum wages across countries. This is a more universal measure for the cross-country comparison. It is found as a ratio of minimum wage to average earnings of a full-time worker. All the wages data used are measured in national currency units and at current prices, to get a percentage rather than a ratio we multiply all the series data by 100%. Average earnings can be defined in two ways, either as median earnings or as mean earnings. For our research objectives both variations of the indicator are employed. Source: OECD.StatExtracts.

- *Product market regulation*

Theoretical foundations. There is no general consensus on the effect of product market regulation on unemployment. Market regulation is associated with government intervention into the market. For classic economic theories government intervention is associated with market inefficiencies that may results in departures from market clearing. Moving away from market clearing conditions means altering equilibrium with the consequential alteration of the capital-labour ratio. That equally might imply an increase or a decrease in unemployment rates.

Variable construction and sources.

Product market regulation indicator has became recently available from OECD database. Unfortunately, that is the reason for its short time-series dimension. The indicator's observations run up only to year 1998. It is also not continuous, so interpolation option has to be used to smooth out the series. Bassanini and Duval (2006) research accompanying dataset has been used to enlarge the series range. Simple rescaling has been used to combine the two datasets. Please note that data has been taken from papers' accompanying website where it has been made available for public use.

- *Trade unions.*

Theoretical foundations. Trade Unions affect labour market processes in a number of ways. One of their primary aspects is their role in the wage setting process between the employee and employer. In a unionised firm employee will have more bargaining power and this will push the wages bargained over upwards. Higher wages would create labour market inefficiencies and cause additional involuntary unemployment. However, as we assume that unions' main objective is welfare of its members this should not affect their decisions. Unions divide labour market into insiders and outsiders depending on their affiliation to trade union. Even though unions do not set wages directly for outsiders they still affect them. While unions may negotiate higher wages for insiders, outsiders hit by unemployment will be willing to work at lower wage rates. Union members will increase wages cyclically even though it could create some unemployment for union members; once they are unemployed they are not considered in the objectives of the union wage setting function. Union behaviour in the wage setting process will also be guided by unemployment conditions of the labour market as a whole. In periods of economic downturns they will not be that demanding as they are likely to be during the periods of high economic growth (Blanchard and Summers (1986)).

The coordination of bargaining processes is crucial to the wage setting process and its effect on economic efficiency. If bargaining is done at higher levels like the economy wide level, then unions no longer distinguish between insiders or outsiders, as their objective is to improve labour market conditions of the overall labour force. Therefore, their objective will be national employment level rather than wage level of a group of people. In this case unions will tend to increase employment level but would lower the wage rates.

In practice wage levels are not the only objective over which unions bargain. They are usually involved in enforcing firing costs, unemployment benefits, featherbedding and decreasing hours worked.

Variable construction and sources.

Two OECD variables are used to measure impact of unionism on unemployment – union density and union coverage. Both of them were sourced from OECD Labour Statistics database.

- *Public expenditures on active labour market policies.*

Theoretical foundations. Active Labour Market Policies are concerned primarily with government-run programs designed to improve employment conditions of the individuals. These programmes compromise public employment services, training, and subsidised employment. All of these programs have different effects on labour market dynamics. Dataset descriptive statistics for ALMP variable by OECD together with accompanying Grubb and Puymoyen (2008) paper helps to familiarise us with the long-time series of public expenditure on ALMP. Summary of the policies provided is listed below.

Public Employment Services programme (PES) is introduced to ease the job search process by providing a free flow of information in labour markets. The programmes usually offer help and support for jobseekers to find matching jobs and motivate them to exert effort in the process. It is initially aimed at enhancing the efficiency of the matching process and removing possible crowding-in effects. Enhanced efficiency of the matching process will affect firm activity through two channels. Firstly, it would lower labour turnover costs of the individual firms thus will lead to increased hiring rates consequently pressing upward aggregate labour demand schedule. Secondly, wage signalling will lose its importance and would result in a decrease in wage rates so labour supply curve will move downwards. Both of the above described shifts in labour supply-demand schedules will lead to a decrease in unemployment. Therefore, according to theory PES programme should reduce frictional unemployment associated with search and matching process.

The PES programmes are not commonly available for all the public but are targeted at more vulnerable groups like youths, women or the disabled. This would have impact on our analysis as this indicator is expected to have more influence on demographic specific employment variables rather than the aggregate ones.

Training Programmes (TP) are equally targeted at both employed and unemployed members of the public. They provide opportunity for some to gain new skills and for others to enhance existing ones to match labour market needs. It would increase labour productivity of employees, thus create additional supply of labour to match the required demand.

However, an increasing "quality" of labour may have adverse effects on the labour market. Firstly, it can raise expected wages of the individuals. Thus, a positive effect of the policy on employment could be offset and labour market steady state will be characterised by higher reservation wages and higher unemployment rates. Secondly, the rise of the lock-in effects can create labour market rigidities resulting in a rise in frictional unemployment. This happens when participants of training either reduce their job search efforts or are tied up by the training programme and not able to enter employment until the training is over.

Subsidised employment is used for the additional job creation. This can be done by subsidising hiring in the private sector, directly creating new working places in the public sector or by assisting the unemployed in becoming entrepreneurs themselves. This policy would stimulate demand of labour, and thus improve employees' position in the bargaining process resulting in the pay rise. The magnitude of unemployment reduced corresponding to the wage rise will depend on the wage elasticity of supply side. If labour supply is completely inelastic, as it is usually common for the short term, then at the cost of wage-rise no unemployment changes will be observed. On the other extreme in the long run with labour force being more flexible and supply being completely elastic, theoretically unemployment will be reduced without any change to wages.

Variable construction and sources.

Public expenditure on ALMP variable was obtained from OECD, Economic Outlook Statistics, 86 and is expressed as a percentage of the GDP. In addition to the general variable, expenditure on ALMP for early retirement has been added to the data sample with the later use for group specific labour market performance regressions.

- *Unemployment benefits*

Theoretical foundations. In a competitive model unemployment benefits would increase individual reservation wages, and would therefore improve employees' position in the wage bargaining process. Wage push would increase unemployment in the labour market. It is argued that unemployment benefits prolong unemployment, as they do not provide an incentive for jobseekers to look for vacancies and they also overstate their earnings expectations. It is argued that a rise in unemployment benefits would permanently affect the natural rate of unemployment (i.e. bring it to a new lower level).

However "unemployment benefits" is not a uniform variable, not everyone is entitled to the same amount of benefits pay out. The actual eligibility or the size of benefits entitled depends on a range of individual conditions (sex, age, number of children, previous working status, duration of unemployment etc.). Here the unemployed are differentiated according to their eligibility for benefits and this will cause ambiguous effects on the labour market. Those not eligible for benefits will have lower reservation wages associated with a rise in unemployment benefits, as the risk of exiting employment will look less desirable. In the meantime for those eligible for benefits reservation wages will be growing.

Variable construction and sources.

Average benefit replacement rate. OECD summary measure of benefit entitlements is used. It is defined as the average of the gross unemployment benefit replacement rates for two earnings levels (100% and 67% of average per week earnings), three family situations (single, married one income earner, married both partners at work) and three durations of unemployment (1 year, 2-3 years, 4-5 years). Data are available only for odd years so we will linearly interpolate it in Stata using the “ipolate” command.

Further two variables construction methodology is based on the method described by Bassanini and Duval (2006 b). Family cash benefit is concerned with the difference of net income for a married couple with two children or without relative to income in the later case. It is assumed that both of the partners earn at 100% of Average Wage. Estimation of second variable “part-time unemployment benefits” is very similar to the family cash benefits variable derivation. It simply compares benefits entitlement in the case of second earner moving to part-time work from being unemployed. Source of data for the variables: Benefits and Wages: OECD Main Tax Benefit Indicators Database.

3.3 Control variables: macroeconomic variables.

- *Output gap.*

Theoretical Foundations*.* Output contractions or expansions are evidence of economic growth and directly indicate job creation/destruction in the economy. Okun’s Law describes an inverse link between change in unemployment and output variables. From the point of view of production function output and employment are positively related. However, marginal product of labour is diminishing over the employment rate. This implies that depending on what level of the technology development country currently is, its rate of output – employment dynamics may slow down over the time under the assumption of no exogenous shocks to the system.

Output gap is the difference between the potential and actual outputs of the economy. It is a procyclical fraction of the GDP and measures disturbances in business cycle due to supply or demand shocks to the economy.

Variable Construction and Sources.

The output gap is a difference between full capacity output level of economy and the actual output level. Full capacity output level theoretically implies output level of the economy when all the production factors are employed: full labour force, optimal levels of the total factor productivity and capital fully employed. However, as potential output is more of an abstract variable it is hard to define. Usually, it is associated with the output where no inflationary pressures are being exerted on the economy. We used output gap variable from OECD database where estimated potential GDP is found by the means of production function. Variable Source: OECD Economic Outlook database.

3.4 Control variables: Macroeconomic volatility measures

- *Exchange rate volatility*

Exchange rate volatility variables detailed derivations are discussed in Chapter 4. Level variables for the estimation have been obtained online from Thomson Reuters 3000 Extra Database. Real effective exchange rate has been used for the analysis. Volatility series compromise 5 alternative variables:
Exchange rate volatility 1 (EV1): rolling standard deviation with lag length of 6 months
Exchange rate volatility 2 (EV2): rolling standard deviation with lag length of 12 month
Exchange rate volatility 3 (EV3): rolling standard deviation with lag length of 18 month
Exchange rate volatility 4 (EV4): ARIMA-GARCH models
Exchange rate volatility 5 (EV5): EGARCH models

- *Inflation volatility*

Inflation volatility variables derivations are discussed in detail in Chapter 5. Inflation series have been approximated by percentage change in GDP deflator series. GDP deflator has been obtained from Economic projection of Economic Outlook database, OECD. Resulting volatility series compromise three alternative measures:
Inflation volatility 1 (PV1): rolling standard deviation with lag length of 4 months
Inflation volatility 2 (PV2): ARFIMA(0,d,0) –GARCH(1,1) models
Inflation volatility 3 (PV3): ARFIMA(0,d,1)-GARCH(1,1) models

- *Interest rate volatility*

Estimation of interest rate volatility is described in more detail in Chapter 6. Interest rate series for the analysis have been approximated by money market rate. This has been obtained mostly from International Monetary Fund's International Financial Statistics database.

Australia: 19360BZF, average rate on money market from IMF, IFS.

Austria: 12260BZF, money market rate (according to IMF, IFS - one day maturity so combined with EU(A) - 16360AZF from IMF as closest to maturity)

Belgium: 12460B.ZF, Call money rate from IMF, IFS based on 3 month EURIBOR, so combined with EU(B) - 16360BZF from IMF as closest in maturity

Canada: 15660BZF, Overnight money market rate from IMF, IFS

Denmark: 12860BZF, Call money rate from IMF, IFS

Finland: 17260BZF, average cost of Central Bank debt from IMF, IFS

France: 13260BZF, call money rate combined with EU(B) - 16360BZF from IMF as closest in maturity

Denmark: 13460BZF, call money rate from IMF, IFS

Ireland: 17860BZF, one month fixed rate from IMF, IFS

Italy: 13660BZF money market rate from IMF, IFS

Japan: 15860BZF, call money rate from IMF, IFS.

Netherlands: 13860BZF, call money rate from IMF, IFS and combined with 16360BZF from IMF as the two are closest in maturity

New Zealand: 19660BZF, money market rate IMF, IFS

Norway: 14260BZF, call money rate from IMF, IFS combined with NIBOR1W, as two are closest in maturity. The later variable taken from Norges bank database

Portugal: 18260BZF, up to 5 days interbank deposit from IMF, IFS combined with EU(A)- 16360AZF from IMF, as two are closest in maturity

Spain: 18460BZF, call money rate from IMF, IFS

Sweden: 14460BZF, call money rate from IMF, IFS

Switzerland: 14660BZF, money market rate from IMF, IFS

United Kingdom: 11260BZF, overnight interbank min from IMF, IFS

United States: 11160BZF, FED funds rate from IMF, IFS

In some cases variables had to be combined to get longer span in terms of time series observations. Any combination has been done by the principle of rescaling. Then volatility measures have been obtained based on the series. Vector of volatility measures consists of four alternative variables:

Interest rate volatility 1 (IRV1): rolling standard deviation with lag length of 12

Interest rate volatility 2 (IRV2): either GARCH model or GJR-GARCH

Interest rate volatility 3 (IRV3): either GARCH or QGARCH models

Interest rate volatility 4 (IRV4): either GARCH or PARCH models

3.5 Other additional control variables considered

- *Life expectancy.*

Longer life expectancy results may result in later retirement and thus higher occupational rates. With the higher life expectancies in Europe many reforms have been passed in order to increase the retirement age. In some of our regression, it has been decided to account for this effect and include the life expectancy variable for the older and retiring age groups. Variable data are obtained from Health Status dataset online form OECD.Stat.

- *Homeownership rates.*

Homeownership rates may play a crucial part in labour market performance. People not owing their home may be more motivated to find employment in order to own their home. However if the homeownership rates are high this can lower job mobility create additional mismatch in labour market and depress employment rates (Blanchflower and Oswald (2013)).

For some of the regressions home-ownership variable has been included to account for the restrictive job mobility affect that has been identified by Oswald (1999). Homeownership rates have been collected from a number of sources. Where gaps in the data observations occurred they have been interpolated to induce continuous series.

Australia homeownership rates have been obtained online from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/1301.0Main+Features1292012

Austria, Belgium, Denmark, Germany, Ireland, Spain, France, Italy, Netherlands, Portugal, Finland, Sweden, Norway, Switzerland homeownership rates are available from EUROSTAT database. Variable name: ilc_lvho02.

Canada Homeownership rates have been extracted online from: http://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-014-x/2011002/c-g/c-g01-eng.cfm

Japan Homeownership Rates: Statistical Survey Department, Statistics bureau, ministry of Internal Affairs and Communications. Available online at www.stat.go.jp/english/data/nenkan/1431-18.htm

New Zealand Homeownership Rates have been obtained online from NZ.Stat from Census data for the years of 2001, 2006 and 2013.

United Kingdom Homeownership data has been obtained online from Office for National Statistics (http://www.ons.gov.uk/ons/rel/census/2011-census-analysis/a-century-of-home-ownership-and-renting-in-england-and-wales/short-story-on-housing.html). Unfortunately, it covers only England and Wales.

United States Homeownership data has been obtained online from two sources: http://www.census.gov/hhes/www/housing/census/historic/owner.html
http://www.census.gov/housing/hvs/data/q214ind.htm

- *Number of kids and childcare costs*

These variables have been previously used by many labour market studies especially those with implications to females participation (e.g. Bassanini and Duval (2006b)).

"Number of kids" variable has been computed following Bassanini and Duval (2006 b) suggestion as number of children per women. For that, population statistics has been obtained from OECD Demography and Population Statistics database that covers data from Eurostat or United Nations. Number of children has been found as a sum of children among age groups of 0-14 years. Number of Women has been found as sum of females among age groups of 25-54 years old. Resulting variable of interest has been found as a proportion of two: number of children and number of women.

"Childcare costs" variable is a ready-made variable available from OECD Benefits and Wages database - Work Incentive statistics. Rather than using public expenditure on childcare costs, as in Bassanini and Duval (2006b), this research is concerned with childcare costs as share of average wages. This is because here the main idea is to capture the work incentive that childcare costs translate onto females' employment rates. Furthermore by default family is assumed to include a couple that are in full-employment earning average wage (100%). Data has been available only for the years 2004, 2008 and 2012. When incorporated into data sample, some observations have been interpolated to create a continuous sample.

Table 3- 1 Descriptive statistics of variables.

Variable name	Number of observations	Mean	Minimum value	Maximum value	Standard deviation
Employment rate	339	58.14	42.18	71.90	5.90
Unemployment rate (ALFS definition)	572	7.39	0.50	26.20	3.96
Harmonised Unemployment Rate	532	7.52	1.56	26.12	3.63
Activity Rates	339	62.28	47.83	73.78	5.14
NAIRU	589	6.97	0.99	21.50	2.99
Number of Discouraged Workers	221	0.65	0.02	9.56	1.05
Duration of unemployment	542	51.42	11.47	100.00	18.81
Tax Wedge	558	29.35	-1.07	49.95	11.10
Employment Protection Legislation	575	2.09	0.26	5.00	0.93
Minimum Wage	307	0.40	0.24	0.59	0.08
Product Market Regulation	575	2.10	0.91	4.10	0.74
Trade Unions	554	36.27	7.55	83.86	20.37
Public expenditures on ALMP	453	0.80	0.13	3.04	0.50
Average benefits replacement rate	540	29.92	0.10	70.95	14.51
Output gap	589	-0.21	-10.49	10.51	2.77
Life expectancy	558	78.27	73.00	83.20	2.20
Homeownership rates	377	68.50	43.80	92.00	8.76
Number of kids	561	0.88	0.63	1.69	0.15
Childcare costs	171	23.59	14.22	3.38	58.15
Exchange rate volatility (EV1)	520	1.00	0.17	4.87	0.62
Exchange rate volatility (EV2)	520	1.15	0.22	4.69	0.70
Exchange rate volatility (EV3)	520	1.12	0.20	4.67	0.68
Exchange rate volatility (EV4)	520	1.98	0.17	15.57	2.08
Exchange rate volatility (EV5)	520	2.06	0.16	14.34	2.10
Inflation volatility (PV1)	564	0.50	0.02	4.19	0.46
Inflation volatility (PV2)	561	0.82	0.01	21.21	1.67
Inflation volatility (PV3)	564	0.82	0.01	22.77	1.74
Interest rate volatility (IRV1)	519	0.66	0.07	6.30	0.88
Interest rate volatility (IRV2)	519	29.25	0.37	1687.59	129.49
Interest rate volatility (IRV3)	519	29.00	0.37	1626.12	127.44
Interest rate volatility (IRV4)	519	26.82	0.21	1026.19	96.39

Chapter 4. Exchange rate volatility effect on labour market performance.

4.1 Derivation of exchange rate volatility series.

Based on the literature review of volatility measures, two methodologies have been selected to estimate exchange rate volatility. These techniques are based on moving standard deviation and conditional heteroskedasticity models. Primary data for volatility measures are obtained from Thomson Reuters 3000 Xtra Database. The OECD real effective exchange rate series start for most countries from the year 1970. However, for some countries starting date may vary so please consult Data and Methodology chapter for more detail.

The monthly exchange rate series were chosen as an optimal compromise frequency of observations for estimating long-run orthodox measures (based on moving standard deviations) and short-run stochastic measures (GARCH based models). The major advantage of higher frequency data is fewer observations are lost during estimation of the final measures. Monthly frequency in financial data enables additional seasonality checks to eliminate such nuisances as “January effect”. Monthly dummy variables have been constructed and regression analysis have been used to test series for any seasonality. The coefficients of OLS regression and their t-test values suggest no seasonality in series.

The estimation of GARCH based measures is build upon technique which steps are described in Brooks (2008) and Franses and Dijk (2000). First, conditional mean has been modelled by ARIMA model. Using Akaike Information Criterion (AIC) and its alternatives best-fit model has been selected. Second, following Bailie and Bollerslev (1992), it has been decided to fit a more broad structure of ARIMA-GARCH for the model rather than simpler but popular version of AR-GARCH. Asymmetric volatility models have been considered, but EGARCH were chosen as the most appropriate one for the purpose (Liu and Morley (2009)).

4.1.1 Unit root tests.

Stationarity of series needs to be established before any fitting of the volatility models can be done. Augmented Dickey Fuller (ADF) tests are the most commonly used among researchers with a null hypothesis of series containing one unit root against alternative of no unit roots. ADF tests suggest the hypothesis of the exchange rate series containing a unit root cannot be rejected at 5% significance level for most of the countries except for Austria, France and Netherlands (in models where the only exogenous variable is a constant). It is highly unlikely for variables with a stochastic nature to be unit root stationary, so for robustness checks of unexpected results (case of Austria, France and Netherlands) further unit root tests are done. Philips-Perron (PP) is a non-parametric version of ADF test, where t-statistic is independent of serial correlation effects. PP tests support the ADF test results for Netherlands and France but disagree with previously established results for Austria. As Philips – Perron test is a more advanced version of ADF test in cases where disputes arise between the two tests results, it is assumed that Philips-Perron results are more authoritative.

Both of the tests used so far assume that series are non-stationary in the null hypothesis and suffer type I and type II errors. Type I error implies rejecting H_0 when it is true and type II error accepting H_0 when H_0 is false. So to minimise type I and type II errors, results robustness checks are done using KPSS tests where null hypothesis of series being stationary is tested against alternative of series being non-stationary (i.e. containing one or more unit roots). KPSS tests' results suggest that hypothesis of exchange rate series being stationary cannot be rejected at 5% significance level for Belgium, Great Britain, Italy, Netherlands, Norway, New Zealand and the US. In a case of Belgium ADF tests confirm non-stationarity of the series, KPSS tests support results of ADF tests for the case where intercept and trend are exogenous at 5% level and in a case where there is only intercept exogenous at 10% significance level. In the case of Great Britain, hypothesis of series being stationary is not rejected only by KPSS test with exogenous constant, but it has been rejected by all ADF, PP tests and KPSS test where constant and trend are exogenous. KPSS tests support Italy and US series non-stationarity but only at 10% significance level, in a case of Netherlands, Norway and New Zealand results are divided depending on the specification. The hypothesis of a series containing one unit root has been mostly not rejected by all of the tests performed here at 10 % significance level subject to the specification of the exogenous structure.

Unit root test results for Austria, Belgium, France, Great Britain, Italy, Netherlands, Norway, New Zealand, and the US still do not permit us to establish firm conclusions. One disadvantage of using long run exchange rate series is increasing chances of them containing structural breaks. For a better grasp on series stationarity nature it has been decided to investigate if there are structural breaks in the unit root that could cause such misleading results. Zivot-Andrews's tests for a single structural break in both trend and intercept have been chosen. Tests of null hypothesis of structural break in unit root against alternative of stationary series with a break have been conducted. Significant evidence gathered indicates that series are unit root stationary with structural break in the series. As further checks it has been decided to split each series sample into two samples in line with the structural breakpoint as identified by Zivot-Andrews test. Then unit root tests have been re-sampled to see whether the stationarity of the series still persists.

For most cases there is overwhelming evidence of series containing one unit root except for Netherlands. In a case of Netherlands structural break in unit root has been confirmed and results of standard unit root tests show that series have been non-stationary before the year 2002, but became stationary afterwards.

From the unit root analysis it can be concluded that most series are non-stationary and contain one unit root except for the exchange rate of Netherlands. The significance of structural break changing the nature of the series cannot be ignored. Additionally to original Netherlands exchange rate volatility variable another two will be created. One covering Netherlands exchange rate series up to and including May 2002 observations and a second one thereafter. Here and further in the analysis, the series will be referred to as Netherlands1 and Netherlands2. Econometric analysis for the pre 2002 sample will be based on the assumption that series contain one unit root. For the second variable, following June 2002, assumptions of stationarity will be made. Thus three variables presenting Netherlands will be treated in further analysis as exchange rate for three different countries with different data samples. Later due course of analysis Netherlands1 combined with Netherlands2 will be used as a substitute for the Netherlands variable.

Overall Structural breaks identified by the AZ tests indicate that robustness checks should be run in panel regressions to control for the Bretton-Woods system collapse, the collapse of USSR and Germany unification, and introduction of Euro. In a case of Netherlands the aim is to test for the overall sample unique volatility variable and then being able to substitute with two volatility variables for the split samples.

Table 4- 2 Unit root tests' results for exchange rate series

Variable	ADF tests' t-stat.			Phillips-Perron adjacent t-stats.	KPSS, LM-Statistic.
	None	Constant	Constant, Linear Trend		

Austria (AT)					
Jan1970 – Jun2011	1.229626 (1)	3.033258 (0)	-2.537860 (1)	-2.295358 (1)	1.690115 (1)
Jan1970 –Sep1996		-1.411047 (1)		-1.411052 (1)	1.777072 (1)
Oct1996 –Jun2011		-3.052385 (0)		-2.582481 (1)	0.322487 (0)
Australia (AU)		-1.892613 (1)			1.065130 (1)
Belgium (BE)					
	0.041734 (1)	-2.065586 (1)	-2.062889 (1)	-1.876878 (1)	0.354807 (0)
Jan1970 - Jun2011					0.201155 (1)
Jan 1970 - Feb1980		-1.279402 (1)		-0.948071(1)	1.155501 (1)
Mar1980 - Jun2011		-2.645501 (1)		-2.760643 (1)	0.481185 (1)
Canada (CA)		-1.721124 (1)			1.243469 (1)
Switzerland (CH)		-2.424613 (1)			1.682668 (1)
Germany (DE)		-2.629619 (1)			0.627077 (1)
Denmark (DK)		-2.114530 (1)			2.009292 (1)
Spain (ES)		-2.293959 (1)			1.516075 (1)
Finland (FI)		-1.586946 (1)			1.273660 (1)
France (FR)					
Jan1970 - Jun2011	-0.336632(1)	-3.475307 (0)	-3.942468 (0)	-2.943624 (0)	1.296928 (1)
Jan1970-Oct1981		-2.949422 (1)*		-2.772350 (1)	0.131068 (0)
Nov1981-Jun2011		-1.463088 (0)		-2.779256 (1)	0.319850 (0)
Great Britain (GB)					
	-0.454557(1)	-2.515876 (1)	-2.488504 (1)	-2.216442 (1)	0.177551 (0)
Jan1972-Jun2011					0.151730 (1)
Jan1972 - Nov1978		-2.784252 (1)		-2.387136 (1)	0.646186 (1)
Dec1978 - Jun2011		-2.465547 (1)		-2.245931 (1)	0.362682 (0)
Ireland (IE)		-1.327699 (1)			1.566014 (1)
Italy (IT)					
	-0.361799 (1)	-2.567159 (1)	-2.466100 (1)	-2.101007 (1)	0.161568 (0)
Jan1970 – Jun2011					0.140270 (0)
Jan1970 - Sep 1992		-1.586414(1)		-1.228684(1)	0.660435(1)
Oct1992 – Jun2011		-1.539210 (1)		-2.116057(1)	1.210993(1)
Japan (JP)		-2.318004 (1)			1.913498 (1)
Netherlands (NL)					
	0.483121 (1)	-3.135786 (0)	-2.835468 (1)	-2.904746 (0)	0.174288 (0)
Jan1970 – Jun2011					0.184521 (1)
Jan1970 - May2002		-2.502628 (1)		-2.521491 (1)	0.499828 (1)
Jun2002 – Jun2011		-3.007261 (0)		-2.914632 (0)	0.173603 (0)
Norway (NO)					
	0.372105(1)	-3.258034 (1)	-3.613596 (0)	-3.212123 (0)	0.183127 (0)
Jan1970 - Jun2012					0.194978 (1)
Jan1970-Oct1992		-2.673096 (1)		-2.495614 (1)	0.588624 (1)
Nov992-Jun2011		-2.611171 (1)		-2.292935 (1)	1.209859 (1)
New Zealand (NZ)					
	0.266437 (1)	-2.464708 (1)	-2.534546(1)	-2.715775(1)	0.245094 (0)

Jan1970 - Jun2011					0.208670 (1)
Jan1970 - Sep 2002		-2.261555 (1)		-2.716686 (1)	0.498519 (1)
Oct 2002 – Jun2011		-2.712093 (1)		-2.795209 (1)	0.131049 (0)
Portugal (PT)		-1.587188 (1)			1.963449 (1)
Sweden (SE)		-1.681040 (1)			2.392213 (1)
United States (US)	-1.044144 (1)	-2.357759 (1)	-2.366598 (1)	-2.180764 (1)	0.405006 (0) 0.127529 (0)

Exchange rate variable is log(REER)
All of the results reported are st 5% s.l., exceptions are * that implies 1% significance level.
ADF tests are performed for a variety of exogenous structures, whereas by default for PP and KPSS tests it is assumed that intercept is exogenous. In some cases there are two KPSS results present, where second line gives results for models where exogenous structure includes both intercept and linear trend.

4.1.2 Descriptive statistics and normality tests

Unit root tests confirmed that all of exchange rate variables are non stationary therefore I(1) variables are used instead, the actual variable that is used for the fitting of volatility models is percentage return of real effective exchange rate:

$$r = 100D[\log(ER)_t], \text{ where } D = \log(ER)_t - \log(ER)_{t-1}$$

However please note that this does not apply to Netherlands 2 as this variable is stationary and does not need differencing. After all data adjustments there are 497 observations left for most of the countries in exchange rate set except for Australia and Great Britain with 473 observations. Mean values from descriptive statistics table suggest that average percentage returns of exchange rate are negative for Canada, Germany, Finland, France, Great Britain, Italy, Sweden and United States implying that on average currency depreciated over the time period. The rest of the countries' exchange rates, on average show appreciation of the currency during the period. The most volatile exchange rate series according to standard deviation measure (more than 2% variation) are for Australia, Japan and New Zealand. Percentage exchange rate return for these countries varies broadly within the range of approximately 22% for Australia, 17% for Japan and 25% for New Zealand.

None of the series distributions considered here are symmetric around their mean value. Most of the series distributions are negatively skewed whereas percentage returns of exchange rate distributions for Austria, Switzerland, Germany, Denmark, Ireland, Japan, Netherlands and Netherlands1 are positively skewed. The "most asymmetric" distribution around its mean is for Spain's exchange rate observations and least asymmetric among the group is US observations' distribution. Skewed distributions usually are one tail longer than the other, this property is apparent in most of the distributions considered. Therefore third moment of all distributions considered is no close to the characteristics of Normal distribution where there are no asymmetries and skewness coefficient is zero.

Turning to the fourth moment of Normal distribution – kurtosis, it can be stated from descriptive analysis table that all of the distributions considered here have fat tails. This result agrees with the expectations as financial data usually has fatter tails. Extreme values of kurtosis coefficient are for exchange rate returns in Spain (29.04), Finland (16.99) and Italy (15.69). Smallest values of kurtosis coefficient and therefore closest to normal distribution parameter (kurtosis coefficient equals three) are in the cases of US, Netherlands, Switzerland, Japan and Austria.

From skewness and kurtosis analysis it can be concluded that distributions of exchange rate return considered in this study do not possess normal distribution characteristics. This has been proved more by Jarque-Berra (JB) Normality tests. Null hypothesis of the test is that distribution is symmetric around mean and has kurtosis coefficient of normal distribution (k=3). JB statistic reject H_0 in all cases.

Table 4- 3 Descriptive statistics and normality test of exchange rate series

	Number of observations	Mean	Median	Maximum	Minimum	St.Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
Austria (AT)	497	0.03	0.00	3.17	-1.89	0.64	0.59	4.69	88.20	0.00
Australia (AU)	473	0.02	0.22	6.55	-15.38	2.48	-1.36	9.02	859.60	0.00
Belgium (BE)	497	0.00	-0.02	2.45	-6.78	0.78	-1.04	13.8	2516.0	0.00
Canada (CA)	497	-0.01	-0.01	5.85	-9.74	1.35	-0.48	8.74	700.96	0.00
Switzerland (CH)	497	0.11	0.03	5.70	-5.87	1.41	0.41	4.14	40.43	0.00
Germany (DE)	497	-0.01	-0.07	6.25	-2.47	0.99	0.94	6.80	373.45	0.00
Denmark (DK)	497	0.043	0.01	4.86	-5.00	0.95	0.04	8.22	564.80	0.00
Spain (ES)	497	0.07	0.11	4.56	-13.81	1.35	-2.88	29.0	14734	0.00
Finland (FI)	497	-0.03	0.01	5.10	-9.70	1.19	-1.82	17.0	4330.9	0.00
France (FR)	497	-0.02	-0.01	3.49	-4.67	0.88	-0.50	6.73	308.92	0.00
Great Britain (GB)	473	-0.04	0.01	7.79	-8.46	1.80	-0.22	5.49	126.32	0.00

Ireland (IE)	497	0.05	0.03	6.36	-7.65	1.36	0.18	6.54	261.49	0.00
Italy (IT)	497	-0.02	0.06	5.47	-8.99	1.28	-1.80	15.7	3617.1	0.00
Japan (JP)	497	0.15	-0.05	10.14	-7.18	2.42	0.63	4.30	67.69	0.00
Netherlands (NL)	497	0.03	-0.01	3.46	-3.06	0.92	0.36	4.08	35.05	0.00
Netherlands1 (NL1)*	388	0.02	-0.02	3.46	-3.06	0.93	0.44	4.29	39.56	0.00
Netherlands2 (NL2)**	109	4.60	4.60	4.63	4.54	0.02	-0.81	2.83	12.13	0.00
Norway (NO)	497	0.02	0.02	5.17	-5.49	1.19	-0.55	6.20	236.53	0.00
New Zealand (NZ)	497	0.03	-0.09	13.20	-12.06	2.21	-0.35	9.04	765.07	0.00
Portugal (PT)	497	0.06	0.04	6.47	-9.59	1.54	-1.19	12.0	1813.5	0.00
Sweden (SE)	497	-0.07	-0.01	5.77	-10.93	1.45	-1.79	14.6	3065.8	0.00
United States (US)	497	-0.08	-0.11	5.43	-4.31	1.34	-0.02	4.02	21.713	0.00

Exchange rate series are 100D[log(REER)$_t$].

All statistics have been done using EViews 7.0 software.

*Netherlands have been split into two variables according to data sample, where * assumes Jan1970 –May2002 and ** assumes Jun2002-Jun2011 (in later data range variables is logREER)

Netherlands sample descriptive characteristics are very similar to Netherlands 1 but are distinctively different from Netherlands 2 series.

4.1.3 Rolling standard deviation model

One of the orthodox measures of volatility is the standard deviation. In order to make it time varying, a rolling standard deviation technique is used. Not only does this help to avoid mean-variance critique (Seabra, 1995), but also accounts for periods of high and low exchange rate uncertainty.

The determination of optimal lag length in the model specification across literature is still subject of dispute. Based on previous studies optimal lag length of m=12 has been chosen as a primary lag length. Further m=6 and m =18 based measures of volatility has been selected for robustness checks of the initial model results.

Even though the measure is time-varying and gives a good approximation for long run volatility measures it has a number of disadvantages. It is still not parametric and does not account for rational behaviour of economic agents, so in discussion of empirical results one needs to take into account that this measure tends to underestimate the actual volatility of exchange rate.

4.1.4 GARCH based measures

Most of previous studies used GARCH (1,1) model as an optimal for modelling exchange rate variability in labour markets. However, it has been decided to extend GARCH models row from ARIMA (0,0) – GARCH (1,1) up to ARIMA (2,2)- GARCH(2,2) models. Modelling is performed in two steps, first ARIMA model is fitted to the series and then only GARCH model is adapted accordingly.

Appropriate ARIMA model specification has to be established for the series. Looking back at descriptive analysis, in particularly guided by autocorrelations and partial autocorrelations correlograms, optimal lag length of 2 is fitted assumed for the ARIMA models. Nine possible models were estimated for percentage return of exchange rate series ranging from ARIMA (0,0) to ARIMA (2,2), then guided by Akaike and Schwartz Information Criterions the best fit models were chosen. Guided by Table 4-3 results, it can be concluded that both criteria give the same model specifications for Belgium, Canada, Switzerland, Germany, Denmark, Spain, France, Finland, France, Great Britain, Ireland, Japan, New Zealand, Sweden and US. In cases where criterions give two different specifications both specifications are retained for further analysis. Results for Netherlands series indicate no need to stick to three variables analysis further. Properties of Netherlands overall sample and Netherlands 1 are very similar according to their econometric nature as has been supported by statics in Descriptive analysis and ARIMA fitting models. Thus it has been decided to omit Netherlands 1 variable from the analysis, as model fitted to Netherlands variable should be of a fit to Netherlands 1 sample.

Table 4- 4 ARIMA models selection for exchange rate series

	AIC best fit model	SIC best fit model
Austria (AT)	ARIMA(2,1)	ARIMA(0,1)
Australia (AU)	ARIMA(1,1)	ARIMA(0,1)
Belgium (BE)	ARIMA(0,1)	ARIMA(0,1)
Canada (CA)	ARIMA(1,0)	ARIMA(1,0)
Switzerland (CH)	ARIMA(0,1)	ARIMA(0,1)
Germany (DE)	ARIMA(0,1)	ARIMA(0,1)
Denmark (DK)	ARIMA(1,2)	ARIMA(1,2)
Spain (ES)	ARIMA(0,1)	ARIMA(0,1)
Finland (FI)	ARIMA(0,1)	ARIMA(0,1)
France (FR)	ARIMA(0,1)	ARIMA(0,1)
Great Britain (GB)	ARIMA(0,1)	ARIMA(0,1)

Ireland (IE)	ARIMA(1,2)	ARIMA(1,2)
Italy (IT)	ARIMA(2,2)	ARIMA(0,1)
Japan (JP)	ARIMA(0,1)	ARIMA(0,1)
Netherlands (NL)	ARIMA(1,2)	ARIMA(0,1)
Netherlands 1 (NL1)	ARIMA(1,2)	ARIMA(0,1)
Netherlands 2 (NL2)	ARIMA(2,2)	ARIMA(2,2)
Norway (NO)	ARIMA(1,2)	ARIMA(0,1)
New Zealand (NZ)	ARIMA(2,2)	ARIMA(2,2)
Portugal (PT)	ARIMA(2,2)	ARIMA(0,0)
Sweden (SE)	ARIMA(0,1)	ARIMA(0,1)
United States (US)	ARIMA(0,1)	ARIMA(0,1)

AIC- Akaike Information Criterion.
SIC –Schwartz information Criterion.
Rule for the best fit is the minimal value of information criterion.

Lagrange multiplier tests for ARCH components need to be done to assure that conditional heteroskedasticity models are appropriate for the data. Series are tested for the detection of ARCH errors for a lag length of 1, 6, and 12 under the null hypothesis of no ARCH effects present, where the lag length is more than one then test is able to capture GARCH type errors. Results for ARCH LM tests are reported in Table 4-4 where conclusions on ARCH effects present are based on the statistical criteria at 5% significance level.

For twelve out of twenty countries' exchange rates considered here, the presence of ARCH effects is confirmed by ARCH LM tests at all lag lengths (1, 6 and 12) indicating the need for GARCH modelling. For countries like Canada, Ireland, Finland and the United States ARCH components are detected only at higher lag lengths signalling towards the presence of GARCH properties. For Austria, Norway and Sweden ARCH effects are detected at starting lag lengths but disappear at higher lag orders of 12 indicating the need for ARCH modelling. One of the core disadvantages of ARCH modelling is the exact definition of lag length order. Recalling that ARCH model with infinite lag length is similar to GARCH (1,1) model, however, gives us advantage of using GARCH modelling for the series. ARCH errors have been detected in most cases except for Spain and Netherlands 2 where all of the tests results favour the null hypothesis of no ARCH effects present. Conditional heteroskedasticity modelling for Spain or Netherlands 2 will not be recalled, as ARCH tests are not so powerful tests to draw final conclusions on. Please remember that additional measure for the robustness checks is to be used (i.e. rolling standard deviation).

Table 4- 5 ARCH LM tests results for exchange rate series

	K=1						K=6						K=12					
	AIC spec		SIC spec.		Presence of ARCH effects		AIC spec		SIC spec.		Presence of ARCH effects		AIC spec		SIC spec.		Presence of ARCH effects	
	F stat	TR^2	F stat	TR^2	AIC	SIC	F stat	TR^2	F stat	TR^2	AIC	SIC	F stat	TR^2	F stat	TR^2	AIC	SIC
AT	4.55	4.53	4.55	4.53	YES	YES	1.13	6.76	1.13	6.76	NO	NO	0.87	10.49	0.95	11.42	NO	NO
AU	10.58	10.39	15.08	14.68	YES	YES	2.99	17.53	3.49	20.34	YES	YES	1.72	20.34	1.88	22.06	YES	YES
BE	17.74	17.19	17.74	17.19	YES	YES	3.20	18.72	3.20	18.72	YES	YES	1.70	20.08	1.70	20.08	YES	YES

CA	0.14	0.14	0.14	0.14	NO	NO	1.13	6.77	1.13	6.77	NO	NO	4.37	48.46	4.37	48.46	YES	YES
CH	8.06	7.96	8.06	7.96	YES	YES	4.88	28.02	4.88	28.02	YES	YES	2.76	31.80	2.76	31.80	YES	YES
DE	101.7	84.65	101.7	84.65	YES	YES	17.75	88.54	17.75	88.54	YES	YES	9.20	91.93	9.20	91.93	YES	YES
DK	26.09	24.88	26.09	24.88	YES	YES	5.28	30.14	5.28	30.14	YES	YES	2.65	30.61	2.65	30.61	YES	YES
ES	0.32	0.32	0.32	0.32	NO	NO	0.13	0.76	0.13	0.76	NO	NO	0.07	0.83	0.07	0.83	NO	NO
FI	0.20	0.20	0.20	0.20	NO	NO	2.00	11.88	2.00	11.88	YES	YES	1.85	21.83	1.85	21.83	YES	YES
FR	15.48	15.07	15.48	15.07	YES	YES	3.43	20.01	3.43	20.01	YES	YES	2.12	24.84	2.12	24.84	YES	YES
GB	17.76	17.18	17.76	17.18	YES	YES	4.90	28.08	4.90	28.08	YES	YES	2.99	34.23	2.99	34.23	YES	YES
IE	2.01	2.01	2.01	2.01	NO	NO	1.61	9.59	1.61	9.59	NO	NO	1.79	21.07	1.79	21.07	YES	YES
IT	50.25	45.78	45.70	42.00	YES	YES	20.30	98.63	19.37	95.06	YES	YES	10.17	99.55	9.74	96.25	YES	YES
JP	7.06	6.99	7.06	6.99	YES	YES	3.44	20.08	3.44	20.08	YES	YES	1.92	22.58	1.92	22.58	YES	YES
NL	10.09	9.92	11.53	11.32	YES	YES	2.69	15.83	3.20	18.70	YES	YES	1.83	21.59	2.05	24.06	YES	YES
NL2	0.59	0.59	0.59	0.59	NO	NO	1.09	6.55	1.09	6.55	NO	NO	1.67	18.66	1.67	18.66	NO*	NO*
NO	8.32	8.21	8.56	8.45	YES	YES	2.77	16.28	2.78	16.33	YES	YES	1.42	16.95	1.44	17.08	NO	NO
NZ	6.58	6.52	6.58	6.52	YES	YES	2.70	15.90	2.70	15.90	YES	YES	1.92	22.61	1.92	22.61	YES	YES
PT	24.98	23.87	25.92	24.73	YES	YES	6.97	39.02	8.96	49.08	YES	YES	8.42	85.42	8.76	88.33	YES	YES
SE	2.73	2.73	2.73	2.73	YES	YES	0.45	2.73	0.45	2.73	NO	NO	0.26	3.16	0.26	3.16	NO	NO
US	0.01	0.01	0.01	0.01	NO	NO	3.37	19.68	3.37	19.68	YES	YES	2.04	23.91	2.04	23.91	YES	YES

AIC and SIC correspond to best-fit models chosen by Akaike and Schwartz Information Criterions respectively.
F-stat and TR^2 statistics have been estimated in EViews 7.0.
K corresponds to lag length of the model, and tests are done at 5% significance level.
*At 10% significance level arch effects are present

The next step in the analysis is to fit a suitable GARCH model. Optimal specification for a GARCH model is chosen from a number of alternatives by the means of forecasting statistics. Gaussian distribution of an error term is assumed for GARCH models settings with heteroskedasticity consistent Bollerslev-Wooldridge coefficient of covariance. Methodology of Bollerslev and Wooldridge (1992) is followed due to non-normality of the series as has been confirmed by the Jarque-Bera tests. Once GARCH models are estimated, then in-sample one-step static forecasts are used to compare the fit of the models similarly to proposed methodology of Liu and Morley (2009). There are 5-7 forecast error statistics estimated together with the forecasts and they are reported in Table 4-5 along with different GARCH based specifications. In many cases statistics give different results and do not reach one unique conclusion, so criteria for a superior forecast has to be defined. Our aim is for forecast errors to have a mean value of 0 (bias proportion close to 0) and small variance proportion to trade-off against a large covariance proportion that implies preference for larger unsystematic errors rather than systematic errors.

Table 4- 6 Forecast error statistics for GARCH based exchange rate volatility models

	RMSE	MAE	MAPE	TIC	BP	VP	CP
AT: GARCH(1,1)	0.638575	0.483600	**101.4812***	0.959077	0.000074	NA	NA
AT: ARIMA(2,1)-GARCH(1,1)	**0.624093***	**0.476794***	135.8271	**0.760697***	0.000225	**0.551972***	0.447804
AT: ARIMA(0,1)-GARCH(1,1)	0.626817	0.477278	131.6684	0.780393	0.000352	0.587962	0.411686
AT: GARCH(2,1)	0.638552	0.483809	102.7115	0.950015	**0.000002***	NA	NA

AU: GARCH(1,1)	2.482679	1.791321	**105.2090***	0.938041	0.003355	NA	NA
AU: ARIMA(1,1)-GARCH(1,1)	**2.405114***	**1.752307***	132.1682	0.745295	0.002015	0.527367	0.47619
AU: ARIMA(0,1)-GARCH(1,1)	2.419197	1.787819	141.8832	**0.738791***	**0.000890***	**0.487127***	0.511983
BE: GARCH(1,1)	0.783539	0.569124	**100.0969***	0.975657	0.000460	NA	NA
BE: ARIMA(0,1)-GARCH(1,1)	**0.735516***	**0.533165***	148.3272	**0.698518***	**0.000379***	0.488948	0.510673
CA: GARCH(1,1)	1.344981	1.008173	**100.4666***	0.984813	0.000101	NA	NA
CA: ARIMA(1,0)-GARCH (1,1)	**1.320620***	**0.989293***	140.1638	**0.820333***	**0.000065***	0.672381	0.327555
CH: GARCH(1,1)	1.407114	1.064499	106.7570*	0.931713	0.000127	NA	NA
CH: ARIMA(0,1)-GARCH(1,1)	**1.352253***	**1.042805***	156.2387	**0.740257***	**0.000003***	0.554989	0.445008
DE: GARCH(1,1)	0.991936	0.746498	**99.39764***	0.986345	0.000564	NA	NA
DE: ARIMA(0,1)-GARCH(1,1)	**0.951361***	**0.718715***	136.1310	**0.764216***	**0.000391***	0.602808	0.396801
DK: GARCH(1,1)	0.950119	0.687893	105.8973	0.940879	0.000280	NA	NA
DK: ARIMA(1,2)-GARCH(1,1)	**0.924337***	**0.661498***	142.9575	**0.756755***	0.000157	0.552177	0.447666
DK: GARCH(1,2)	0.950036	0.687200	**101.8187***	0.965246	**0.000104***	NA	NA
FI: GARCH(1,1)	1.190652	0.745995	**101.5000***	0.981995	0.000083	NA	NA
FI: ARIMA(0,1)-GARCH(1,1)	**1.145943***	**0.711635***	145.9227	**0.773707***	**0.000014***	0.620745	0.379241
FR: GARCH(1,1)	0.883371	0.622685	**100.0227***	0.974735	0.000058	NA	NA
FR: ARIMA(0,1)-GARCH(1,1)	**0.847956***	**0.592037***	163.7052	**0.724772***	**0.000057***	0.496937	0.503006
GB: GARCH(1,1)	1.801772	1.291461	**101.2750***	0.990199	**0.000189***	NA	NA
GB: ARIMA(0,1)-GARCH(1,1)	**1.720077***	**1.277445***	189.2689	**0.763507***	0.000221	0.617034	0.382746
IE: GARCH (1,1)	1.364181	0.991546	112.4342	0.922163	0.002661	NA	NA
IE: ARIMA(1,2)-GARCH(1,1)	**1.327827***	**0.957057***	136.4848	**0.766475***	0.003523	0.587244	0.409233
IE: GARCH(1,2)	1.362926	0.990077	**107.2170***	0.941213	**0.000823***	NA	NA
IT: GARCH(1,1)	1.283613	0.783269	**107.6825***	0.962442	0.003313	NA	NA
IT: ARIMA(2,2)-GARCH(1,1)	**1.191375***	**0.736845***	166.2361	**0.698706***	0.008868	**0.536344***	0.454788
IT: GARCH(2,2)	1.283636	0.783264	107.7794	0.962173	0.003349	NA	NA
IT: ARIMA(0,1) –GARCH(1,1)	1.211788	0.738790	146.1811	0.735532	**0.002169***	0.573013	0.424818
JP: GARCH(1,1)	2.415762	1.808122	**108.9233***	0.930204	0.000158	NA	NA
JP: ARIMA(0,1)-GARCH(1,1)	**2.295530***	**1.765507***	138.8581	**0.724852***	**0.000001***	0.537468	0.462531
NL: GARCH(1,1)	0.913420	0.689285	107.7331	0.952022	0.000511	NA	NA
NL: ARIMA(1,2)-GARCH(1,1)	**0.854728***	**0.660072***	181.3459	**0.678646***	0.000260	**0.446586***	0.553153
NL: ARIMA(0,1) – GARCH(1,1)	0866468	0.667095	162.0987	0.723805	**0.000507***	0.534009	0.465484
NL: GARCH(1,2)	0.913460	0.689385	**108.2177***	0.950364	0.000600	NA	NA
NO: GARCH(1,1)	1.187507	0.840713	**99.02724***	0.989560	0.000084	NA	NA
NO: ARIMA(1,2) –GARCH(1,1)	**1.149783***	0.830024	173.9883	**0.769851***	0.000005	**0.592583***	0.407412
NO: ARIMA(0,1)-GARCH(1,1)	1.160133	**0.821865***	148.4281	0.793093	0.000038	0.619083	0.380879
NO: GARCH(1,2)	1.187457	0.840606	99.81517	0.981699	**0.000001***	NA	NA
NZ: GARCH(1,1)	2.204611	1.530696	**101.4824***	0.984861	**0.000005***	NA	NA
NZ: ARIMA(2,2)-GARCH(1,1)	**2.113181***	**1.398728***	168.1382	**0.709984***	0.000018	0.465985	0.533998
NZ: GARCH(2,2)	2.204800	1.533410	105.1359	0.974319	0.000176	NA	NA
PT: GARCH(1,1)	**1.535655***	0.948935	**112.8855***	0.946782	**0.000355***	NA	NA
PT: ARMA(2,2)-GARCH(1,1)	1.537817	**0.946839***	159.2286	**0.796695***	0.000865	0.563977	0.435158
PT: GARCH(2,2)	1.535860	0.949567	115.5632	0.941469	0.000622	NA	NA
SE: GARCH(1,1)	1.454548	0.946364	**100.7221***	0.988190	0.003652	NA	NA
SE: ARMA(0,1)-GARCH(1,1)	**1.400251***	**0.924517***	172.2789	**0.778450***	**0.001831***	0.624790	0.373380
US: GARCH(1,1)	1.334635	1.016366	**111.8134***	0.940504	0.000005	NA	NA
US: ARIMA(0,1)-GARCH(1,1)	**1.270449***	**0.955963***	139.3733	**0.716892***	**0.000001***	0.509040	0.490958

1.Optimal specification by our judgement of the forecasting test results is written in bold.

2.RMSE- square root of mean squared error, MAE –Mean Absolute Error, MAPE – mean absolute percentage error, TIC – Theil's Information Criteria, BP – Bias Proportion, VP – Variance Proportion, CP –Covariance Proportion.

*The best specification among country's specifications listed according to specific test.

Square root of mean square error (RMSE), mean absolute error (MAE) and mean absolute percentage error (MAPE) are measures based on the difference of forecasted and actual residuals. There is a need to note that mostly MAPE is a common statistic used by researchers (e.g. Makridakis and Hibon (1995), Brooks and Burke (1998)). The main drawback of these measures is that they are sensitive to scaling and measure units of the variable. Please recall that our variable is GARCH model of the percentage change of exchange rate (100*d [log ($REER_t$)]), so it is hard to interpret the meaning of statistics

The analysis will be concerned more with Theil's Information Criteria because this is the only available scale free measure. However, Theil's statistic similarly to MSE penalises outliers or any large errors (effect of news on the market) stronger than small errors. A very useful forecasting test statistic for exchange rate volatility is Z score (correct sign prediction). Not only the value of change matters for the exchange rate, but also most importantly the nature of change (i.e. appreciation or depreciation) is the vital predictor. Unfortunately this test is not available to us in EViews.

For half of the countries present in the study (AU, BE, CA, CH, DE, FI, FR, JP, SE and US) model choice is easy and is where both bias proportion and Theil's Information Criteria are the smallest. In other cases decision making will be harder, like in the case of Austria, where out of four possible models only one can be rejected according to statistics – ARIMA(0,1) –GARCH (1,1). GARCH(2,2) is our choice for the best model. Even though it has high values of both squared residual statistics and TIC statistics, its MAPE value is second best and most importantly its bias proportion is very low, indicating better mean modelling. Since the concern is equations of first and second moments, cases where BP value is the smallest is preferred. Similarly in cases of Denmark, Great Britain, Ireland, New Zealand and Portugal, model will be chosen with the smallest bias proportion and MAPE values. In case of Italy and Netherlands the model with smallest bias and second best indicators of RMSE, MAE and TIC is picked. In the case of Norway the value with the smallest mean bias and second best indicator for MAPE is selected. Please note that the cases of Spain or Netherlands 2 are not discussed here, as there was no overwhelming evidence found for the presence of ARCH effects. Still GARCH (1,1) model will be fit to them.

4.1.5 EGARCH based measures.

Exchange rates have common characteristic – asymmetry that needs to be accounted for in heteroskedastic models, so EGARCH model will be used. Nelson (1991) technique is followed and GED distribution is assumed. For most of the countries EGARCH (1,1) model will be fit, but for Austria, Denmark, Ireland, Italy, Netherlands, Norway, New Zealand and Portugal forecasting techniques are used to choose best fit from the alternatives.

Results of forecast statistics are in Table 4-6. Easiest decision-making has been for the case of Norway where all of the forecasting test statistics agreed on one specification. Overall decision-making here is easier than for general GARCH models. There are only five statistics and a specification choice of one out of two. So decision rule is to choose specification with at least three statistics favouring the model, but also not to forget the difference in mean values (BP). And it has indeed coincided in all of the cases. Results for different countries can be seen in Table 4-6.

Table 4- 7 Forecast errors for EGARCH models of exchange rate volatility

	RMSE	MAE	MAPE	TIC	BP
AT: EGARCH(1,1)	0.639340	0.483255*	99.00208*	0.999644	0.002466
AT: EGARCH(2,1)	0.638889*	0.483328	99.47188	0.982089*	0.001057*
DK: EGARCH(1,1)	0.950120	0.687112*	101.0231*	0.971507	0.000282
DK: EGARCH(1,2)	0.950042*	0.687193	101.7480	0.965798*	0.000116*
IE: EGARCH (1,1)	1.363683	0.990944*	110.5833	0.928371*	0.001932
IE: EGARCH(1,2)	1.363228*	0.990410	108.6716*	0.935355	0.001265*
IT: EGARCH(1,1)	1.284017*	0.783206	109.3778*	0.957930	0.003939*
IT: EGARCH(2,2)	1.284080	0.783204*	109.6443	0.957261*	0.004037
NL: EGARCH(1,1)	0.913191*	0.688335*	102.9625*	0.969662	0.000011*
NL: EGARCH(1,2)	0.913204	0.688459	103.6284	0.966913*	0.000038
NO: EGARCH(1,1)	1.187521	0.840734	98.92774	0.990805	0.000109
NO: EGARCH(1,2)	1.187460*	0.840604*	99.58523*	0.983013*	0.000006*
NZ: EGARCH(1,1)	2.206708*	1.524155	101.1921*	0.971175	0.001904*
NZ: EGARCH(2,2)	2.206804	1.524107*	101.3998	0.970287*	0.001991
PT: EGARCH(1,1)	1.535401	0.947830*	104.2686*	0.968324	0.000023
PT: EGARCH(2,2)	1.535388*	0.948003	106.6966	0.961447*	0.000006*

Optimal specification by our judgement of the forecasting test results is written in bold.
RMSE- square root of mean squared error, MAE –Mean Absolute Error, MAPE – mean absolute percentage error, TIC – Theil's Information Criteria, BP – Bias Proportion.
*The best specification among country's specifications listed according to specific test.

4.1.6 Volatility measures descriptive statistics.

Estimated volatility measures have been averaged from monthly to yearly frequency. Descriptive statistics describing the final estimated volatility models of exchange rate series are present in Table 4-7. Additionally, in Appendix A3 different exchange rate volatility measures have been plotted.

By looking at the appendix A3 plots, from the scaling of axes it becomes apparent that standard deviation based volatility measures on average are smaller in magnitude than those based on GARCH models. On average across countries, highest range of values belongs to ARIMA-GARCH based models (15.4), followed by EGARCH (14.8), and standard deviation measure with lag length of 6 months (4.7). The rest of the measures have similar data range of 4.7. As expected, standard deviation based measures not only correspond to smaller data range, but also to a smaller standard deviation of the data.

Observing the first three sections of Appendix A3, differences within rolling standard deviation measures can be noticed. Technically the only difference between the measures lies in the choice of optimal lag length. Even though measures are in close value ranges to each other, shapes of the curves do differ. In the first graph of EV1 measure, the curve is more flat comparatively to other graphs with a smaller distinction of the peak values. In the second graph closer to the end of period, the peak value is 0.979. In the third graph, there is emergence of the two peak values - one at the start of the period, another towards the end. Here, graph appears as a transitory between standard deviation based measures and GARCH based ones, as there is clear appearance of the two sideway peaks and flattening of the in-between curve section. Graphs based on GARCH modelling resemble white noise bounded by the two value peaks. They have similar, but not identical shapes. Asymmetric modelling of exchange rates by the means of EGARCH produces results with higher standard deviation, whereas GARCH based measure gives higher peak value. Here, it looks that if the lag length of the rolling standard deviation keeps increasing infinitely it will reach GARCH based volatility measure.

These observational results are not unique and differ across countries. Similarly to Australia, for Canada, Finland, Italy, New Zealand, Portugal and Spain, different volatility models produce different characteristics of the volatility measures (i.e. peaks position, number and value). For the rest of the countries models produce not identical, but in general terms similar plot shapes without apparent differences.

Even results on range, minimum value, maximum value, mean and standard deviation are dependant on the country choice. However, one general conclusion can be drawn. There is more similarity among parametric measures (GARCH based) than between rolling standard deviation ones. There are still differences within parametric models. In general, asymmetric models produce higher peaks, but flatter intervals in between.

Table 4-8 Descriptive statistics and normality tests of yearly volatility measures of exchange rate series for OECD countries during 1985-2011

	Number of observations	Mean	Median	Maximum	Minimum	St. Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
Austria (AT)										
MA6	40	0.530	0.519	0.875	0.173	0.171	0.147	2.691	0.304	0.859
MA12	40	0.580	0.600	0.979	0.200	0.172	0.063	2.864	0.058	0.972
MA18	39	0.594	0.600	1.003	0.225	0.170	-0.044	2.705	0.154	0.926
GARCH (2,1)	40	0.415	0.424	0.669	0.166	0.125	-0.175	2.283	1.060	0.589
EGARCH (2,1)	40	0.414	0.429	0.623	0.158	0.117	-0.276	2.456	1.001	0.606
Australia (AU)										
MA6	38	1.985	1.851	3.548	0.947	0.687	0.738	2.904	3.464	0.177
MA12	38	2.188	2.055	4.580	1.006	0.822	1.118	4.357	10.837	0.004
MA18	37	2.278	2.194	4.617	1.087	0.775	0.979	4.256	8.347	0.015
ARIMA(0,1) - GARCH(1,1)	38	5.957	5.327	14.371	4.008	2.208	2.327	8.380	80.116	0.000
EGARCH (1,1)	38	6.077	5.511	11.419	4.209	1.835	1.628	5.148	24.082	0.000
Belgium (BE)										
MA6	40	0.595	0.562	1.545	0.262	0.203	2.611	13.184	218.281	0.000
MA12	40	0.671	0.632	1.817	0.298	0.242	2.659	13.831	242.656	0.000
MA18	39	0.706	0.665	1.543	0.386	0.222	1.976	8.265	70.438	0.000
ARIMA(0,1)-GARCH(1,1)	40	0.537	0.504	1.490	0.409	0.165	4.940	29.098	1297.838	0.000
EGARCH(1,1)	40	0.598	0.570	1.580	0.421	0.184	3.892	21.492	670.894	0.000
Canada (CA)										
MA6	40	1.053	0.978	2.310	0.500	0.398	1.467	5.575	25.390	0.000
MA12	40	1.161	1.065	2.920	0.673	0.452	1.954	7.566	60.194	0.000
MA18	39	1.207	1.077	2.942	0.729	0.454	1.923	7.238	53.224	0.000
ARIMA(1,0)-GARCH(1,1)	40	1.788	1.398	7.076	0.874	1.154	2.923	12.689	213.445	0.000
EGARCH(1,1)	40	1.777	1.525	4.813	0.761	0.860	1.674	5.855	32.267	0.000
Switzerland (CH)										
MA6	40	1.116	1.073	2.166	0.571	0.315	0.941	4.586	10.093	0.006
MA12	40	1.243	1.245	2.422	0.724	0.337	1.043	5.086	14.512	0.001
MA18	39	1.302	1.260	2.633	0.846	0.340	1.560	7.209	44.595	0.000
ARIMA(0,1)-GARCH(1,1)	40	1.845	1.764	3.652	1.345	0.431	2.016	8.907	85.267	0.000
EGARCH(1,1)	40	1.972	1.923	4.179	1.347	0.491	2.264	11.307	149.191	0.000
Germany (DE)										
MA6	40	0.788	0.736	1.939	0.418	0.271	2.037	9.355	94.980	0.000

	Number of observations	Mean	Median	Maximum	Minimum	St. Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
MA12	40	0.869	0.827	1.909	0.433	0.284	1.585	6.602	38.379	0.000
MA18	39	0.908	0.878	2.200	0.446	0.291	2.282	11.152	141.840	0.000
ARIMA(0,1)-GARCH(1,1)	40	0.907	0.835	2.321	0.594	0.321	2.926	12.567	209.640	0.000
EGARCH(1,1)	40	0.977	0.923	2.199	0.583	0.295	2.104	9.116	91.851	0.000
Denmark (DK)										
MA6	40	0.746	0.688	1.647	0.290	0.304	1.296	4.694	15.988	0.000
MA12	40	0.832	0.766	1.873	0.349	0.330	1.301	4.704	16.118	0.000
MA18	39	0.870	0.803	1.572	0.382	0.311	0.649	2.647	2.942	0.230
ARIMA(1,2)-GARCH(1,1)	40	0.915	0.797	2.769	0.543	0.412	2.822	12.139	192.293	0.000
EGARCH(1,2)	40	0.887	0.784	2.278	0.482	0.370	1.720	6.459	39.670	0.000
Spain (ES)										
MA6	40	0.950	0.748	3.107	0.479	0.557	1.949	7.177	54.397	0.000
MA12	40	1.077	0.878	2.698	0.493	0.583	1.399	3.953	14.558	0.001
MA18	39	1.144	0.953	3.418	0.543	0.649	1.712	5.878	32.517	0.000
GARCH(1,1)	40	2.260	1.457	9.819	0.427	2.247	1.799	5.919	35.786	0.000
EGARCH(1,1)	40	1.566	1.455	3.939	0.585	0.896	0.966	3.016	6.227	0.044
Finland (FI)										
MA6	40	0.830	0.730	2.389	0.255	0.455	1.559	5.703	28.379	0.000
MA12	40	0.935	0.801	2.921	0.316	0.519	1.697	6.674	41.689	0.000
MA18	39	0.992	0.845	2.825	0.345	0.510	1.537	5.756	27.688	0.000
ARIMA(0,1) - GARCH(1,1)	40	1.405	1.119	5.205	0.655	0.842	2.683	11.667	173.189	0.000
EGARCH(1,1)	40	1.369	1.071	6.116	0.500	1.038	2.835	12.699	210.395	0.000
France (FR)										
MA6	40	0.667	0.599	1.591	0.292	0.310	1.495	4.961	21.307	0.000
MA12	40	0.751	0.650	1.630	0.328	0.323	1.183	3.873	10.608	0.005
MA18	39	0.798	0.720	1.511	0.344	0.319	0.891	2.884	5.178	0.075
ARIMA(0,1) - GARCH(1,1)	40	0.792	0.589	2.430	0.246	0.527	1.458	4.410	17.477	0.000
EGARCH(1,1)	40	0.798	0.659	2.218	0.304	0.455	1.820	5.757	34.743	0.000
Great Britain (GB)										
MA6	38	1.384	1.259	2.595	0.669	0.504	0.670	2.573	3.130	0.209
MA12	38	1.561	1.495	2.950	0.752	0.543	0.781	3.048	3.869	0.144
MA18	37	1.629	1.574	2.806	0.787	0.511	0.398	2.319	1.694	0.429
GARCH(1,1)	38	3.405	2.843	6.713	1.968	1.390	1.018	2.891	6.588	0.037
EGARCH(1,1)	38	3.345	2.920	6.417	1.942	1.261	0.831	2.428	4.889	0.087
Ireland (IE)										
MA6	40	1.085	0.990	2.524	0.284	0.517	0.969	3.574	6.804	0.033
MA12	40	1.181	1.024	2.497	0.335	0.540	0.851	3.130	4.855	0.088
MA18	39	1.237	1.188	2.501	0.408	0.510	0.718	2.946	3.357	0.187
GARCH(1,2)	40	2.106	1.603	6.502	0.430	1.601	1.588	4.660	21.401	0.000
EGARCH(1,2)	40	1.964	1.759	5.302	0.292	1.254	1.158	3.729	9.820	0.007

	Number of observations	Mean	Median	Maximum	Minimum	St. Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
Italy (IT)										
MA6	40	0.836	0.651	2.754	0.177	0.615	1.952	5.974	40.148	0.000
MA12	40	0.954	0.779	3.027	0.232	0.675	1.850	5.746	35.372	0.000
MA18	39	1.026	0.768	2.861	0.295	0.677	1.348	3.535	12.280	0.002
ARIMA(0,1) - GARCH(1,1)	40	1.797	0.880	10.140	0.308	2.532	2.299	6.874	60.256	0.000
EGARCH(1,1)	40	1.759	0.860	11.061	0.197	2.482	2.474	8.076	83.756	0.000
Japan (JP)										
MA6	40	1.920	1.830	3.086	0.883	0.579	0.315	2.289	1.502	0.472
MA12	40	2.137	2.138	3.686	0.953	0.617	0.362	2.785	0.950	0.622
MA18	39	2.246	2.137	3.626	1.145	0.596	0.314	2.401	1.223	0.542
ARIMA(0,1) - GARCH(1,1)	40	5.145	5.169	8.083	1.950	1.555	-0.165	2.167	1.340	0.512
EGARCH(1,1)	40	5.975	5.595	8.265	4.735	0.950	0.882	2.839	5.231	0.073
Netherlands (NL)										
MA6	40	0.741	0.753	1.231	0.326	0.208	0.259	2.563	0.764	0.683
MA12	40	0.811	0.778	1.476	0.438	0.221	0.741	3.539	4.141	0.126
MA18	39	0.847	0.822	1.434	0.521	0.199	0.672	3.283	3.067	0.216
ARIMA(0,1) - GARCH(1,1)	40	0.764	0.753	1.267	0.440	0.154	0.694	4.502	6.973	0.031
EGARCH(1,1)	40	0.845	0.817	1.169	0.462	0.162	0.093	2.815	0.114	0.945
Netherlands 1										
MA6	31	0.755	0.775	1.231	0.326	0.213	0.153	2.704	0.234	0.889
MA12	31	0.828	0.798	1.476	0.438	0.231	0.660	3.438	2.498	0.287
MA18	30	0.867	0.828	1.434	0.521	0.200	0.720	3.458	2.858	0.240
ARIMA(0,1) - GARCH(1,1)	31	0.765	0.756	1.057	0.625	0.098	1.030	3.904	6.536	0.038
EGARCH(1,1)	31	0.852	0.824	1.144	0.657	0.131	0.665	2.667	2.430	0.297
Netherlands 2										
MA6	8	0.0003	0.0003	0.0008	0.0001	0.0002	1.7152	4.9665	5.2115	0.0738
MA12	8	0.0004	0.0002	0.0012	0.0001	0.0003	2.0687	5.6765	8.0937	0.0175
MA18	7	0.0111	0.0098	0.0201	0.0055	0.0048	0.9568	2.9865	1.0680	0.5862
GARCH(1,1)	7	0.0128	0.0130	0.0223	0.0069	0.0051	0.7730	2.7976	0.7090	0.7015
EGARCH(1,1)	8	0.0084	0.0080	0.0140	0.0053	0.0030	0.6993	2.4747	0.7439	0.6894
Norway (NO)										
MA6	40	0.934	0.785	2.071	0.258	0.414	0.746	3.037	3.713	0.156
MA12	40	1.042	1.037	2.340	0.274	0.407	0.877	4.342	8.133	0.017
MA18	39	1.087	1.063	2.136	0.342	0.388	0.610	3.245	2.520	0.284
GARCH(1,2)	40	1.456	1.245	3.341	0.843	0.547	1.595	5.632	28.504	0.000
EGARCH(1,2)	40	1.491	1.352	3.056	0.597	0.614	0.943	3.162	5.969	0.051
New Zealand (NZ)										
MA6	40	1.669	1.474	4.873	0.701	0.805	1.826	7.534	56.502	0.000

	Number of observations	Mean	Median	Maximum	Minimum	St. Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
MA12	40	1.848	1.671	4.667	0.794	0.880	1.440	5.056	20.870	0.000
MA18	39	1.940	1.715	4.686	0.849	0.908	1.343	4.460	15.178	0.001
GARCH(1,1)	40	4.941	3.884	15.572	2.100	3.096	2.094	7.339	60.629	0.000
EGARCH(1,1)	40	4.903	4.359	14.342	1.229	2.799	1.335	4.965	18.321	0.000
Portugal (PT)										
MA6	40	1.084	0.830	4.089	0.244	0.834	1.648	5.699	30.244	0.000
MA12	40	1.189	0.921	4.019	0.346	0.887	1.473	4.791	19.815	0.000
MA18	39	1.229	0.919	3.980	0.404	0.897	1.361	4.343	14.965	0.001
GARCH(1,1)	40	2.557	1.124	15.237	0.239	3.496	2.314	8.190	80.571	0.000
EGARCH(2,2)	40	2.211	1.258	12.986	0.237	2.715	2.350	8.856	93.986	0.000
Sweden (SE)										
MA6	40	1.066	1.011	2.459	0.386	0.477	0.952	3.846	7.233	0.027
MA12	40	1.197	1.054	2.902	0.422	0.588	1.066	3.787	8.613	0.013
MA18	39	1.259	1.089	2.760	0.432	0.587	0.918	3.247	5.575	0.062
ARIMA(0,1) - GARCH(1,1)	40	1.987	1.846	3.508	1.639	0.419	2.256	7.780	72.003	0.000
EGARCH(1,1)	40	2.110	1.749	7.513	0.763	1.372	2.080	7.854	68.102	0.000
United States (US)										
MA6	40	1.064	1.075	1.765	0.444	0.357	0.045	2.140	1.247	0.536
MA12	40	1.177	1.171	1.920	0.459	0.366	0.025	2.208	1.048	0.592
MA18	39	1.230	1.256	1.907	0.494	0.339	-0.050	2.407	0.588	0.745
ARIMA(0,1) - GARCH(1,1)	40	1.675	1.563	2.906	0.663	0.572	0.553	2.477	2.492	0.288
EGARCH(1,1)	40	1.861	1.838	3.153	0.607	0.658	0.266	2.311	1.263	0.532

Please note volatility measures and all relevant analysis are estimated using EViews 7.0 except for Netherlands 2 that has been estimated using EViews 8.0.

4.2 Exchange rate volatility effect on labour market performance.

Based on literature review in Chapter 2, it is expected that exchange rate volatility will have a negative effect on labour market performance. Belke and Setzer (2003) find a link between exchange rate volatility and unemployment. They show that volatility of the exchange rate lowers job creation within industry. Low supply of jobs in the labour market increases unemployment, intensifies competition for jobs, creates additional discouraged labour force, and prolongs unemployment spells. Empirically, adverse effects of exchange rate volatility on labour market performance has been proven by studies of Belke and Gross(1996), Buscher and Mueller(1999), Belke and Setzer(2003), Belke and Kaas(2004), Chang et.al.(2007), Demir (2010), and Feldmann (2011).

Labour market performance and its determinants are modelled using a number of panel estimation techniques. Choice of the appropriate methods was guided by technical econometric characteristics without omitting practical implications. Particular emphasis is done on the panel time series nature of the macroeconomic model that distinguishes itself from the wealth of microeconomics based estimation instruments (Eberhardt (2012)). However, sensitivity analyses for the robustness of the model are not limited only by the technical aspects, but furthermore include additional variables of interest, alternative variable estimates to the existing ones and sample size manipulations.

On the technical side, please note that for all econometric analysis in this section the STATA SE 13.1 software has been used.

4.2.1 Baseline model derivations

Baseline specification is aimed at defining determinants of the labour market performance for the overall population sample of those who are 15 years and over. Here, core labour performance indicator is chosen to be the unemployment rate and exchange rate volatility indicator is chosen to be moving standard deviation with lag length of 6 months. Further choice of the determinants of the labour market performance is done in such a way as to retain a maximum attainable number of observations per panel group. After all adjustments and permutations have been done, it has resulted in unbalanced panel of equally spaced observations ranging from 1985 to 2010. Baseline specification in OLS form is:

$$U_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it},$$

where U_{it} is Unemployment Rate, X_{it} is a vector of explanatory variables, α_i is country fixed effects, that vary only between countries but not over time, d_t is time dummies for years in the regression sample except one and u_{it} is idiosyncratic error term that varies over time and between countries.

As a starting point, a pooled OLS model has been fitted, with fixed time effects and clustered by countries. Yearly dummies are included for years 1986-2010. Results are reported in Table 4-8. According to regression results, exchange rate volatility is inversely related to unemployment rate, but relationship is highly insignificant with corresponding p value of 0.631. Theoretically results are unexpected, but could be explained by currency arbitrage creating extra work places. This would characterise decision makers as risk takers.

What about other variables result in the regression? Positive highly significant relationship has been found between output gap and unemployment. This is in line with the previous literature (e.g. Elmeskov(1998), Nicoletti and Scarpetta(2004)).

It has been found that tax wedge has positive impact on unemployment, 10% increase in tax rate is associated with 1.4% increase in unemployment rate. This result is in line with previous studies. Belot and Van Ours (2001) found that 10% increase in tax rate is accompanied by a 1.2% rise in unemployment rate in 18 OECD countries during the period of 1960-1994. Overall, significance and direction of the result is tolerant with previous studies of Bassanini and Duval (2006a), Blanchard and Wolfers (2000), Daveri and Tabellini(2000), and Elmeskov et.al. (1998).

According to the regression results, tightening of product market regulation results in higher unemployment rates. However, the result is insignificant. This is in line with previous studies of Feldman(2012) and Bassanini and Duval(2009). Similarly, coefficient of the employment protection legislation variable is insignificant in the estimated regression equation. Still, results suggest that stricter employment protection policies are characterised by lower unemployment rates. Results of previous studies in the area have been split on the significance and direction of the effect. Even though Bassanini and Duval (2006 a) found no significant result, their estimates suggest that strict employment protection legislation is associated with higher unemployment rate. Studies of Blanchard and Wolfers (2000) found that employment protection legislation has a significant positive effect on unemployment. Elmeskov et.al. (1998) found that EPL always has significantly positive impact on structural unemployment in all of the regressions for OECD 19 countries during 1983-1995. Furthermore, Furceri and Morougane (2009) found that in countries with high EPL, rise in unemployment as a consequence of a severe downturn could be doubled in comparison to countries with weak EPL policies. Nickel (1998) found no significant relationship between EPL policy strictness and unemployment in 20 OECD countries during 1983-1994. However, in the short-run it tends to decrease unemployment rate, but in the long-term it tends to increase it.

Belot and Van Ours(2001) estimated a negative relationship between EPL and unemployment level. Introduction of the EPL into regression equation reduces unemployment by almost 3%. Daveri and Tabellini(2000) confirmed a negative effect of the EPL on unemployment in the study of 14 OECD countries during the years of 1965-1995. However, in the reduced form regression, first difference of the EPL variable becomes insignificant.

Regression results are indicative of a positive insignificant relationship among average benefit replacement rates and unemployment rate. Direction of the relationship is in line with previous studies of Bassanini and Duval (2006), Blanchards and Wolfers(2000), Bone and Van Ours(2004), Belot and Van Ours(2001), Daveri and Tabellini(2000), and IMF (2003). However in most of the studies concerned with OECD countries the relationship has been found of high significance.

Previous studies of Belot and Van Ours (2001), Blanchard and Wolfers, Boone and Van Ours(2004), IMF (2003), Nickel (1998), Nunziata(2002) and Scarpeta (1996) found positive relationship between union density and unemployment rate. Not in all of the studies relationship was significant. Our regression results contradict the studies as it looks as if higher unionisation is associated with smaller unemployment rates.

Most coefficients in the regression equation are in line with the previous studies, except for exchange rate volatility and trade union density variables. Standard errors in the model are very large, without exception of exchange rate volatility, their biasness is suspected. If there is one, then coefficient estimates are unreliable and R squared values are artificially high. It has been decided to run diagnostic checks of the residuals of the OLS model. Correlation matrix obtained is evident of serial correlation present in the model as coefficients range from 0.27 to 0.99. For additional checks of serial correlation in panel data Wooldridge's (2002) test is used. It tests the null hypothesis of no serial correlation against alternative of first order autocorrelation of the error term. This test is robust to within panel correlation i.e. data clustering within groups thus produces heteroskedasticity consistent estimates. Estimated F-test value statistic of 118.286 and its corresponding p value of 0.000 provide strong evidence in favour of autocorrelated idiosyncratic error terms.

It is clear that pooled OLS model does not represent a reliable tool to estimate this labour market case. A more advanced panel data models are needed to cope with unobservable elements of the regression, namely country effects.

Next step is to estimate model using Fixed Effects (FE) or Random Effects (RE) models. Regression results based on FE and RE models have been estimated (Table 4-8). Contrary to pooled OLS technique, estimation of the equation using FE and RE derived a highly significant positive relationship between exchange rate volatility and unemployment rate. Corresponding coefficients and p values are for RE model 0.524(0.018) and for FE model 0.511(0.022). Standard errors have been reduced dramatically once alternative estimation methods have been used. Both techniques account for unobservable country effects but address the issue differently. Main distinction in ways to tackle the problem of unobservable term lies in the presumptions of its statistical behaviour in relationship to other variables in the regression. FE model proposes demeaning the data that eliminates the unobservable part from the resulting regression equation. Theoretical advantage of the above is that it does not need to restrict collinearity between country effects term and other explanatory variables in the equation. It is being a disadvantage of the RE model that presumes zero collinearity. Advantage of the RE model over FE is its capability to estimate categorical dummy variables that do not vary over time. Demeaning of the data in FE model eliminates not only unobservable element of the equation but all time-invariant variables. This does not seem to be a problem for baseline specification, as no time invariant variables are included in the explanatory variables vector. FE method appeals more to the model, as assumption of no collinearity practically seems to be too restrictive. Hausman test is done to aid with the choice between the RE and FE models. Chi squared value of 6.01 with its corresponding value of 0.5387 leads to conclude that difference in coefficients is not systematic so RE estimator is consistent and efficient.

For the assurance of RE model's econometric dominance over pooled OLS, Breusch-Pagan Lagrange Multiplier test is run for the null hypothesis of no significant difference across countries in the sample. Resulting test statistic (chi squared) of 3138.67 and its associated p value of 0.0000 are indicative of RE method providing a better estimate of the model than pooled OLS due to the country specific effects being present.

Table 4-9 Determinants of unemployment (including exchange rate volatility) for OECD countries (1985-2011)

	Pooled OLS (clustered by country)	Fixed effects	Random effects	Random effects (with erv2)	Random effects (with erv3)	Random effects (with erv4)	Random effects (with erv5)
Exchange rate volatility (EV1)	-0.426	0.511**	0.524**				
Exchange rate volatility (EV2)				0.593***			
Exchange rate volatility (EV3)					0.560***		
Exchange rate volatility (EV4)						0.126	
Exchange rate volatility (EV5)							0.154**
Output Gap	-0.509***	-0.526***	-0.536***	-0.534***	-0.533***	-0.546***	-0.538***
Tax Wedge	0.146**	0.137***	0.130***	0.130***	0.129***	0.126***	0.130***
Product Market Regulation	2.188	0.629*	0.657**	0.604*	0.618*	0.704*	0.692**
Employment Protection Legislation	-0.630	0.922*	0.440	0.398	0.419	0.461	0.465
Average Benefit Replacement Rate	0.009	0.103***	0.088***	0.090***	0.090***	0.084***	0.086***
Union Density	-0.043	-0.021	-0.397*	-0.042*	-0.041*	-0.037*	-0.038*
Time Effects	YES	YES	YES	YES	YES	YES	YES
Standard Error of Exchange Rate Volatility	0.852	0.223	0.221	0.202	0.202	0.079	0.078
R^2 within		0.599	0.597	0.600	0.599	0.594	0.596
R^2 between		0.049	0.073	0.069	0.069	0.077	0.073
R^2 overall	0.358	0.167	0.226	0.226	0.224	0.229	0.226
Time Effects F-test	12.97 (0.000)	2.07 (0.002)	51.83 (0.001)	51.30 (0.002)	52.67 (0.001)	49.10 (0.003)	50.59 (0.0018)
Wooldridge test (2005)	118.296 (0.0000)						
Mod. Wald Test for Heteroskedasticity		633.68 (0.000)					
Hausmann test[1]		6.01 (0.539)	6.01 (0.539)				
Breusch-Pagan LM Test	3138.67 (0.000)		3138.67 (0.000)				
Average Number of Years[2]	24.1	24.1	24.1	24.1	24.1	24.1	24.1
Number of Countries	20	20	20	20	20	20	20
Number of Observations	482	482	482	482	482	482	482

Baseline specification: $Urt = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$[1]

[1] Hausman test results reported are based on regressions without time effects.

[2] Average number of years is used as panel is unbalanced

* result is significant at 10% significance level
** result is significant at 5% significance level
*** result is significant at 1% significance level

4.2.2 Exchange rate volatility measures

Five alternative exchange rate volatility measures have been built for the purpose of this research. Three of the measures are based on moving average behavioural model of the exchange rate series and only differ by the time span of intervals. The other two measures are GARCH based volatility measures that differ only by the symmetry of response assumptions. Baseline specification of unemployment determinants inclusive of different volatility indicators has been estimated using Random Effects model. Results are reported in Table 4-8. Time effects have been included for all regressions as has been suggested by F-tests that are reported.

Estimated coefficients in the regressions for exchange rate volatility are clustered by the nature of technique used. Parametric models' volatility yields smaller coefficients than the non–parametric one. For moving average based estimations volatility coefficients range from 0.524 to 0.593, and results are highly significant even at 1% significance level. In case of GARCH based models, coefficients range from 0.126 to 0.154 with the first result being insignificant and second being significant at 5% significance level. Absolute values of coefficients among the groups are not perfectly comparable. Moving average based indicator and unemployment rate are in percentages and log-linear levels whereas GARCH based measures are hard to translate into units.

Standard errors of the exchange rate volatility variable are reported in the table. Smallest standard errors are for the mixed parametric measure of exchange rate volatility. Usually smaller standard errors represent the more robust results. Largest standard errors are for the baseline specification with volatility measure based on moving standard deviation with the smallest lag length of 6 months. Larger standard errors create larger confidence intervals and less reliable estimates. These findings are in line with the expectations outlined in Chapter 2 of this research. However, higher standard errors in moving average models are accompanied by longer lag length and this could be a signal that exchange rates and volatility have longer memories than expected. According to analysis probably the best performing measures of volatility are for the parametric – mixed GARCH model and for the non-parametric ones the largest lag length produces better estimate.

As for the other explanatory variables in the regressions they are within the range despite the type of volatility measure used in the regression. For the output gap, tax wedge, average benefit replacement rate coefficients appear to be highly significant at 1% significance level, for union density variable significance of the relationship is smaller at 10% significance level. Employment protection legislation has no significant impact on unemployment rate according to all of the regressions discussed here. Significance of product market regulation on unemployment formation varies across regressions from weakly significant 10% to significant level of 5%. Overall results are in line with the previous findings reported in this research.

4.2.3 Labour market performance dynamics

A significant amount of evidence has been gathered in favour of a positive linear relationship among exchange rate volatility and unemployment rate. However, unemployment rate is only a tip of an iceberg among labour market indicators available. This subsection aims to find how exchange rate volatility affects labour market performance by the means of different indicators that hopefully would help in drawing up a bit more detailed mechanism of interrelationships.

The standard deviation of exchange rate variable is used for all specifications, but also drawing on previous section conclusions, exchange rate volatility indicator based on longer lag length is chosen (m=18 months). All results are reported in Table 4-9. Baseline specification for unemployment rate where EV3 indicator has been used was carried forward from Table 4-8 to Table 4-9 for comparison reasons.

The employment indicator of labour market performance is a complementary indicator to the unemployment rate. One would expect an inverse relationship between the two. This is not the case here, where according to results exchange rate volatility and employment rate sustain a positive relationship. Moreover reported result is highly significant even at 1% significance level. Concluding from above, exchange rate volatility increases both unemployment and employment rates. These results have not been expected contemporaneously and it was decided to use alternative unemployment rate indicator in the analysis.

Harmonised unemployment rate variable is superior to a standard unemployment rate collected from Annual Labour Force Surveys. The later one is suited for a cross-country comparison, but comes at a cost of fewer available observations. Still it is expected it will produce more reliable results. Once unemployment rate has been substituted by an alternative in baseline specification, results responded to it as well. It was found that exchange rate volatility lowers unemployment rate, so the direction of the relationship between the two variables has undergone coordinal change. Relationship is highly significant as before, but the coefficient of the exchange rate volatility has increased in absolute terms by almost 50%. These contrary results could be a consequence of either unemployment rate variable having poor performance for cross-section data analysis, econometric issues with the model, or exchange rate volatility affecting unemployment through transitional mechanisms that have spill over effects to both variables. Despite how contradictory these findings are, further analyses indicate that exchange rate volatility increases labour force participation rates and decreases inactivity rates. Logically it accomplishes these results based on harmonised unemployment rate. However things are not as smooth as they look. Exchange rate volatility increases number of discouraged workers. Result is not just highly significant but is large in magnitude – could be explanation for the contradictory results. As number of discouraged workers increases pool of unemployment decreases in size giving mixed misleading signals of lower unemployment and higher employment rates. Similarly can have mixed effect on activity and inactivity rates. Furthermore it has been shown to have no significant effect on short-term unemployment duration of less than six months.

Non-accelerating inflation rate of unemployment is another alternative variable to unemployment rate. It is indicator of structural unemployment and tracks long-term unemployment rate. According to regression analysis, exchange rate volatility increases structural unemployment rate in the long run. This fits to overall picture as well to support hypothesis of exchange rate volatility increasing unemployment rate, while mimicking the opposite effect through its discouraged workers link.

Table 4-10 Determinants of labour market performance for OECD countries (1985-2011) including exchange rate volatility indicators

	Baseline specification (y = unemployment rate)	y = employment rate	y = HUR[1]	y = activity rate (participation rate)	y = inactivity rate	y = NAIRU[2]	y = discouraged workers	y =duration of unemployment less than 6 moths
Exchange rate volatility (EV3)	0.560***	0.580***	-0.775***	0.508**	-0.506**	0.222**	0.297**	0.349
Output Gap	-0.533***	0.326***	-0.518***	0.076**	-0.077**	-0.167***	-0.079*	1.407***
Tax Wedge	0.129***	-0.182***	0.072***	-0.150***	0.149***	0.098***	0.006	-0.595***

	Baseline specification (y = unemployment rate)	y = employment rate	y = HUR[1]	y = activity rate (participation rate)	y = inactivity rate	y = NAIRU[2]	y = discouraged workers	y =duration of unemployment less than 6 moths
Product Market Regulation	0.618*	-0.565	2.407***	-1.033*	1.026*	0.114	1.244***	-0.878**
Employment Protection Legislation	0.419	2.933***	-0.536***	1.803***	1.786***	-0.538**	0.038	-3.221**
Average Benefit Replacement Rate	0.090***	-0.000	-0.008	0.019	-0.019	0.077***	-0.016**	-0.150*
Union Density	-0.041*	-0.084***	-0.030***	-0.042	0.042	-0.051***	0.021***	0.117
Time Effects	YES	YES	YES	YES	YES	YES	YES	YES
Standard Error of Exchange Rate Volatility	0.202	0.245	0.290	0.022	0.199	0.111	0.008	0.942
R^2 within	0.599	0.568	0.502	0.434	0.4307	0.519	0.573	0.436
R^2 between	0.069	0.014	0.193	0.099	0.099	0.003	0.501	0.317
R^2 overall	0.224	0.028	0.324	0.096	0.096	0.021	0.658	0.351
Average number of years	24.1	13.1	22	13.1	13.1	24.1	11.9	23.2
Number of countries	20	20	20	20	20	20	15	20
Number of observations	482	262	440	262	262	482	178	465

Specification: $y = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$, *where y is labour market performance indicator*

[1] HUR =Harmonised unemployment rate

[2] NAIRU = Non-accelerating inflation rate of unemployment

[3] Dummy variables are included for the years of 1991, 2000 and 2008

* result is significant at 10% significance level

** result is significant at 5% significance level

*** result is significant at 1% significance level

If it is indeed omitted variable bias that has created autocorrelation in the residuals, then it is possible to remedy it. All regressions have been re-run using random effects model with standard errors that are robust to autocorrelation. Results are indicative that autocorrelation is to be blamed for the previously achieved spurious results.

First of all there is consensus between unemployment indicators that are used here. According to the results, exchange rate volatility creates additional unemployment rates increase, and now it is not only the sign of prediction, but the coefficients' values are very close too. Results are significant at 10% level. For both regressions, composite exchange rate volatility indicator has been used, as it is most significant.

There is a balancing counter relationship between volatility and employment rate. Exchange rate volatility decreases employment rate as was predicted theoretically, but practically this result is insignificant so volatility has no impact on employment levels. What about structural unemployment? It looks like exchange rate volatility causes some structural disturbances but insignificant result and value of the coefficient (0.001) suggest the opposite. There is no relationship between NAIRU and ERV. Similarly, no evidence has been found for the existence of relationship between ERV and activity, inactivity rates and unemployment duration. However estimated coefficients' direction of proposed relationship is in line with initial expectations.

The most surprising result still has been for regressions where discouraged workers numbers are explained. It appears that ERV is still significant in regressions for all ERV indicators. Once again, results for composite indicator of volatility are reported as they produce most significant estimates. So it appears that the highest impact exchange rate volatility has on discouraged workers, more precisely it increases the numbers of them.

Table 4-11 Determinants of labour market performance for OECD countries (1985-2011), where estimation technique is robust to residuals autocorrelation

	Baseline specification (y = unemployment rate)	y = employment rate	y = HUR[1]	y = activity rate (participation rate)	y = inactivity rate	y = NAIRU[2]	y = discouraged workers	y =duration of unemployment less than 6 moths
Exchange rate volatility (EV1)		-0.025		-0.032	0.022	0.001		0.094
Exchange rate volatility (EV5)	0.061*		0.063*				0.146***	
Output Gap	-0.328***	0.239***	-0.334***	0.083***	-0.086***	-0.060***	-0.092**	0.709***
Tax Wedge	0.028**	-0.075***	0.028***	-0.051***	0.051***	0.012**	0.032***	-0.176**
Product Market Regulation	-0.094	0.201	-0.397	-0.144	0.106	-0.181	1.182***	2.305
Employment Protection Regulation	0.034	0.628	-0.337	-0.034	0.042	-0.410**	-0.135	-2.779
Average Benefit Replacement Rate	0.011	0.008	0.012	0.021	-0.022	0.004	-0.003	0.019
Union Density	0.053**	-0.045	0.040*	-0.020	0.020	0.046***	0.009	-0.079
Time Effects	YES	YES	YES	YES	YES	YES	YES	YES
Standard Error of Exchange Rate Volatility	0.035	0.129	0.034	0.091	0.091	0.036	0.056	0.575

	Baseline specification (y = unemployment rate)	y = employment rate	y = HUR[1]	y = activity rate (participation rate)	y = inactivity rate	y = NAIRU[2]	y = discouraged workers	y =duration of unemployment less than 6 moths
R^2 within	0.509	0.456	0.557	0.296	0.295	0.332	0.590	0.382
R^2 between	0.006	0.012	0.034	0.185	0.183	0.006	0.315	0.122
R^2 overall	0.081	0.033	0.077	0.177	0.175	0.002	0.582	0.175
Average Number of Years	24.1	13.1	22	13.1	13.1	24.1	11.9	23.2
Number of countries	20	20	20	20	20	20	15	20
Number of observations	482	262	440	262	262	482	178	465

[1] HUR =Harmonised unemployment rate
[2] NAIRU =Non-accelerating inflation rate of unemployment
* result is significant at 10% significance level
** result is significant at 5% significance level
*** result is significant at 1% significance level

This result fits into previous studies conclusions from literature review. In particular with results of Belke and Setzer (2003) and Belke and Kaas (2004), who proposed that exchange rate volatility increases displacement rates, and thus causes a decline in unemployment. Previously stated hypothesis has not been tested here due to a lack of displacement rates data. However, it has been found that exchange rate volatility provokes unemployed to withdraw from labour force. Contemporaneous effect of volatility on unemployment and discouraged workers implies that it is larger than estimated. So to conclude estimates reported in regressions (1) and (3) are smaller than theoretically projected due to discouraged workers effect.

4.2.4 Minimum wage legislation

Minimum wage legislation is another important labour market policy indicator. However, it has not been added to the baseline regression as it requires special econometric treatment of the model. This is because minimum wage legislation has not been passed in every country in the data sample but only in 12 out of 20.

Starting with the baseline specification where the minimum wage indicator in relation to median wages is used. Once additional variable is included in the regression it absorbs all the significance from the output gap, the exchange rate volatility and the union density variables. The nature of the relationship between volatility and exchange rate remains the same – positive. When the unemployment rate is substituted for harmonised unemployment rate indicator, the nature of the relationship changes but it becomes highly significant. What is even more remarkable is that minimum wage level results are mixed for both regressions: higher minimum wage increases harmonised unemployment rate, but decreases unemployment rate. Contradictory results are confusing, as based on R squared results, within countries effect is better explained by the first model whereas between countries effect is better explained by the second.

It has been decided to define a new Minimum wage indicator ("minw_d") to preserve as many countries as possible in the sample and to achieve a higher number of total observations. A binary variable has been created that takes a value of 0 if country does not have minimum wage and 1 if it has minimum wage for this year. The new variable is a mixed variable, as for some countries it is time invariant where minimum wage has not been set, whilst for others it is time variant where minimum legislation has been passed. Minimum wage indicator has been substituted back to baseline regression that was estimated using RE method. Regressions have been run for both unemployment rate and harmonised unemployment rate. Directionally there were no changes for exchange rate volatility impact on unemployment indicators however both results became highly significant. In unemployment rate regression, exchange rate volatility coefficient magnitude has decreased slightly whereas in harmonised unemployment regression it has been reduced dramatically from 1.995 to 0.788. Overall, the power of the models is very weak in contrast to the first two regressions. After a closer look one may see that according to R squared value of within effects regressions with a binary variable outperform the other ones. It is the between effect that is poorly explained by the regressions. One of the possible reasons for that is inappropriate technique used for estimation. After minimum wage variable has been transformed to binary it became a mixed variable of level 1 and level 2 properties.

Alternative to RE modelling is FE, but binary minimum wage is a categorical variable and for some countries where it is time-invariant FE model will produce no estimate for it. There is a class of models that is similar to RE but less restrictive, they are hybrid (Allison (2009)) and correlated RE models (Mundalak(1978)). From the name of technique one could guess that it relaxes restrictive assumption of RE model of no correlation between country effects and vector of explanatory variables.

Correlated RE effects model has been fitted to baseline specification with hybrid levels 1 and 2 indicator of minimum wage for both cases where dependant variable is unemployment rate and harmonised unemployment rate. Fitting of hybrid and correlated random effects model together with the Wald tests has been done in STATA based on Schunck (2013) proposed methodology. For both regressions, exchange rate volatility increases the unemployment rate. But also it loses its high significance and becomes weakly significant and even insignificant at 10% significance level for unemployment rate. For mean values of exchange rate volatility direction of relationship is opposite, given an increase in between country volatility decreases unemployment rate in both cases. Still despite the loss of significance, the results have finally reached a consensus on the directional aspect of the relationship. Similarly, minimum wage indicator decreases unemployment but the results are weakly significant. R squared values have substantially improved for the between effects going from 0.077 to 0.43 and from 0.099 to 0.388. Such an improvement was expected as correlated RE model includes "between" term –mean values of explanatory variables- to account for the between effects. Model choice between RE and correlated RE depends on the Wald test parameter of the mean values coefficients being equal to 0. If the mean value coefficient is equal to 0 then our model is reduced to RE model, and if not – then the correlated RE is a better fit.

Table 4-12 Determinants of labour market performance for OECD countries (1985-2011) including minimum wage indicators

	(1)Baseline specification (with minw1 added) (1)	(2):Baseline specification (1) where Y=HUR[1]	(3): Baseline specification (with binary indicator minimum wage added)(2)	(4): Specification (3) with Y=HUR	(5) Specification (3) using hybrid models[2]	(6)Specification (3) using correlated RE model	(7) Specification (4) using hybrid models	(8) Specification (4) using correlated RE
Exchange rate Volatility (EV3)	0.650	-1.995***	0.566***	-0.788***		0.288		0.310*
Output Gap	-0.017	-0.380***	-0.535***	-0.519***		-0.514***		-0.489***
Tax Wedge	-0.287***	0.022	0.135***	0.075***		0.129***		0.093***
Product Market Regulation	-8.420***	4.216***	0.630**	2.327***		0.569***		-0.105
Employment Protection Legislation	2.650***	-0.709***	0.432	-0.505***		0.826*		1.15***
Average Benefit Replacement Rate	-0.171***	-0.028	0.091***	-0.010		0.092***		0.090***
Union Density	-0.023	-0.075***	-0.38*	-0.023**		-0.039		0.017
Minimum Wage	-0.398	5.354						
Minimum Wage (binary indicator)			0.287	0.381	-0.264	-0.261	-0.950*	-0.988*
Demeaned Output Gap					-0.514***		-0.490***	
Demeaned Tax Wedge					0.129***		0.093***	
Demeaned EV3					0.288		0.311*	
Demeaned Product Market Regulation					0.569***		-0.104	

Demeaned Employment Protection Legislation					0.826*		1.14**	-
Demeaned Average Benefit Replacement Rate					0.092***		0.090***	
Demeaned Union Density					-0.39		0.017	
Mean Output Gap					2.294*	2.814*	2.373**	2.886*
Mean Tax Wedge					0.040	-0.088	0.038	-0.053
Mean EV3					-0.570	-0.842	-0.204	-0.457
Mean Product Market Regulation					5.464**	4.902	4.981**	5.156
Mean Employment Protection Legislation					-1.026	-1.852	-0.952	-2.114*
Mean Average Benefit Replacement Rate					0.002	-0.091	0.005	-0.083
Mean Union Density					-0.019	0.020	-0.032	0.050
Time Effects	YES	YES	YES	YES	NO	NO	NO	NO
Year dummies[3]	NO	NO	NO	NO	YES	YES	YES	YES
Wald Parameter Test[2]					0.28 (0.5991)	0.15 (0.6948)	0.15 (0.6968)	0.05 (0.8247)
R^2 within	0.4904	0.352	0.599	0.434	0.573	0.573	0.591	0.591
R^2 between	0.3588	0.412	0.077	0.099	0.430	0.430	0.388	0.388
R^2 overall	0.3878	0.373	0.230	0.096	0.472	0.472	0.457	0.457
Average Number of Years	21.3	21.2	24.1	13.1	22.0	22.0	22.0	22.0
Number of countries	12	12	20	20	20	20	20	20
Number of observations	256	254	482	262	440	440	440	440

Specification: $y = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$, where y is unemployment rate
[1] HUR =Harmonised unemployment rate
[2] Hybrid and correlated RE methods and Wald test statistics have been adapted from Schunck (2013)
[3] Dummy variables are included for the years of 1991, 2000 and 2008
* result is significant at 10% significance level
** result is significant at 5% significance level
*** result is significant at 1% significance level

Wald parameter test is indicative of distinctive between and within effects that supports correlated RE modelling.

Hybrid model is also built on the RE model by a matter of simple mathematical permutation – addition and subtraction of mean explanatory variables vector. Mean values subtracted from its original values vector produce “within” effects estimator and additional mean values variable provides a good “between” effects estimator. Increase in exchange rate volatility over time within countries increases unemployment rate for both indicators (ALFS and HUR). But once again an increase in the average exchange rate volatility between countries decreases. Here once again R squared values for between and overall have improved substantially. Furthermore Wald test for the distinction of between and within effects, coefficients of mean value being equal to within proves for the need of hybrid modelling.

Minimum wage variable indifferent to technique used appeared to have no significant effect on unemployment in most regressions. However minimum wage based regression put some clarity on the question of exchange rate volatility effect on unemployment. One can conclude that effect is different for between and within data estimators. Once it is split into two it becomes clear that for within country data exchange rate volatility increases unemployment. But across countries higher average exchange rate volatility deceases unemployment level. This paradox could be explained by Central Banks interventions and increased economics integrity when facing external risks. Government actions aimed to protect against increased exchange rate volatility are a more effective option than intervening into the foreign exchange market. As a consequence, one may get an illusion of increased exchange rate volatility accompanied by an increase in activity rates and higher employment rates.

4.2.5 Sensitivity analysis for the baseline model

4.2.5.1 Time effects

Further diagnostic tests of the model have to be done so as to ensure that the assumptions of the models are not violated and the results are not misleading. Time series wise data sample is long covering 25 years of observations. Large time span can result in outliers being present in the sample due to one off historical events that are not in the scope of this study. In order to control for those time fixed effects yearly dummies have been used in all of the regressions with one exception for the analysis using Hausman test. Use of yearly dummies has been supported F tests results reported in Table 4-8. Omission of the yearly dummies in Hausman test regressions has been done to avoid artificially high chi squared statistic and overly high significant corresponding p values. For example, in our latest choice of RE versus FE model (Table 4-8) inclusion of time dummies would increase chi squared statistic to 6.54 and corresponding p value to 1.000.

Table 4-13 Determinants of unemployment for OECD countries (1985-2011): time effects

(1)Baseline specification	(2) Baseline Specification including time effects	(3)Baseline Specification including yearly dummies[1]	(4) Baseline Specification excluding years 1991, 2000 and 2008

Exchange rate volatility (EV1)	0.423**	0.511**	0.417**	0.455**
Output Gap	-0.519***	-0.536***	-0.517***	-0.526***
Tax Wedge	0.136***	0.137***	0.136***	0.129***
Product Market Regulation	0.435***	0.629*	0.391***	0.462***
Employment Protection Legislation	0.270	0.922*	0.284	0.201
Average Benefit Replacement Rate	0.086***	0.103***	0.087***	0.089***
Union Density	-0.033*	-0.021	-0.034*	-0.035*
Time Effects	NO	YES	NO	NO
Time Dummies[1]	NO	NO	YES	NO
Standard Error of Exchange Rate Volatility	0.204	0.223	0.206	0.224
R^2 within	0.549	0.599	0.553	0.534
R^2 between	0.072	0.049	0.071	0.078
R^2 overall	0.212	0.167	0.211	0.213
Average number of years[2]	24.1	24.1	24.1	21.2
Number of countries	20	20	20	20
Number of observations	482	482	482	424

Baseline specification: $Urt = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$, Urt – unemployment rate for over 15 years old.

[1] Dummy variables are included for the years of 1991, 2000 and 2008

* result is significant at 10% significance level

** result is significant at 5% significance level

*** result is significant at 1% significance level

Sample data range manipulations could help to perform robustness checks of whether time effects still have impact on regression results. There are a number of historical dates in the data sample that potentially could have caused outlier effects in the analysis. They are – East and West Germany unification of 1989 and the collapse of USSR in 1991, the introduction of the Euro in 1998 and its circulation in 2000, and the latest financial crisis of 2008. So three dummy variables have been used to account for those potential structural breaks for the years - 1991, 2000 and 2008. As an alternative to time effects it has been decided to use three dummy variables to control specifically only for those events. Results are present in Table 4-12. It has been shown that regardless of how the time effects are addressed, the results are robust and exchange rate volatility has significant relatively small contribution to unemployment. This result has been confirmed by both the inclusion of specific yearly dummies or the removal of associated year's observations from the data. Results for regression without time effects and for those that are modified have exchange rate volatility in close range of 0.417 to 0.511 and corresponding p-values are within 5% significance level.

4.2.5.2 Country effects

There are only 20 countries present in the data sample. As every country contributes roughly 5% of all observations, one country can potentially bias the overall result. Results robust to specific country mix can be obtained by rolling country-by-country exclusion from the data sample and further reassessment of the results. Results of the regression manipulations are reported in Table 4-13.

Most of results have suggested that there is no single country spill over in the sample. Exchange rate volatility coefficient ranges for most of the regressions within the interval of 0.418 to 0.643. Results are highly significant with p-values in a range of 0.06 to 0.044. The only exception is Finland and Sweden. These Scandinavian countries have an overwhelming effect on the whole of the analysis of unemployment rate determination. For example in case for Sweden, once corresponding observations are removed from the sample, exchange rate looses double of its coefficient value and drops its significance level to 27.5%. This could be indicative that our results misrepresent the overall labour market picture, but instead show more a Swedish economy case that has higher weights in the sample. One of the ways to avoid this bias is to include a large number of world economies and re-run the regressions. Unfortunately this is out of the scope of this analysis, but could serve as a suggestion for further research.

Table 4-14 Individual country's effects in baseline model of unemployment determination that includes exchange rate volatility

Country[1]	EV1	p-value of EV1	R squared within	R squared between	R squared overall	Number of observations
Australia	0.571	0.014	0.599	0.07	0.228	467
Austria	0.532	0.019	0.606	0.072	0.227	456
Belgium	0.540	0.017	0.592	0.054	0.207	456
Canada	0.643	0.006	0602	0.112	0.265	456
Denmark	0.536	0.018	0.592	0.064	0.202	456
Finland	0.214	0.317	0.614	0.100	0.219	456
France	0.526	0.019	0.597	0.062	0.221	465
Germany	0.517	0.021	0.604	0.066	0.224	462

Country[1]	EV1	p-value of EV1	R squared within	R squared between	R squared overall	Number of observations
Ireland	0.502	0.027	0.535	0.132	0.241	461
Italy	0.632	0.006	0.620	0.059	0.201	456
Japan	0.626	0.008	0.612	0.046	0.212	456
Netherlands	0.570	0.010	0.595	0.094	0.251	456
New Zealand	0.643	0.007	0.592	0.078	0.229	461
Norway	0.562	0.018	0.598	0.099	0.247	456
Portugal	0.522	0.019	0.609	0.091	0.235	456
Spain	0.418	0.025	0.662	0.036	0.239	456
Sweden	0.248	0.275	0.607	0.094	0.241	456
Switzerland	0.537	0.018	0.600	0.055	0.235	456
United Kingdom	0.474	0.044	0.593	0.072	0.219	456
United States	0.485	0.035	0.610	0.066	0.229	458

[1]Country excluded from the observations in the data sample
Baseline specification: $\mathrm{Urt} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$

It has been found that baseline model results are sensitive to the country's composition in the data. In particular it has been established that once observations for Finland and Sweden are dropped, the volatility of exchange rate looses in its significance and value. In order to see whether this result is valid for alternative volatility estimators, regressions where Sweden has been excluded form the data sample has been re-run. Instead of a more crude measure of unemployment rate (by ALFS) it has been decided to substitute it with harmonised unemployment rate due to its better between country comparability. All results are reported in Table 4-14.

Table 4-15 Determinants of unemployment for OECD countries except for Sweden

	(1)Baseline specification with EV1	(2) Baseline Specification with EV2	(3)Baseline Specification with EV3	(4)Baseline Specification with EV4	(5) Baseline Specification with EV5
Exchange rate volatility (EV1)	-0.500*				
Exchange rate volatility (EV2)		-0.565**			
Exchange rate volatility (EV3)			-0.511*		
Exchange rate volatility (EV4)				-0.541	
Exchange rate volatility (EV5)					-0.249***

Output Gap	-0.515***	-0.507***	-0.509***	-0.513***	-0.514***
Tax Wedge	0.081***	0.077***	0.079***	0.087***	0.070***
Product Market Regulation	1.685***	2.030***	1.918***	1.275***	2.087***
Employment Protection Legislation	-0.327	-0.395*	-0.374*	-0.233	-0.397**
Average Benefit Replacement Rate	-0.006	-0.010	-0.008	0.002	-0.013
Union Density	-0.025*	-0.023**	-0.024**	-0.027**	-0.023**
Time Effects	YES	YES	YES	YES	YES
R^2 within	0.585	0.567	0.573	0.600	0.564
R^2 between	0.176	0.185	0.182	0.151	0.195
R^2 overall	0.323	0.328	0.326	0.308	0.335
Average Number of years	21.8	21.8	21.8	21.8	21.8
Number of observations	414	414	414	414	414

Baseline specification: $Urt = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$, *where Urt is harmonised unemployment rate*
* result is significant at 10% significance level
** result is significant at 5% significance level
*** result is significant at 1% significance level

Results for alternative measures suggest that there is significant relationship between exchange rate volatility and unemployment rate even in the absence of the Swedish observations. However, as can be seen from the results, direction of relationship between ERV and harmonised unemployment rate is orthogonal to that derived by the ALFS unemployment rate indicator. As sensitivity of the results to Swedish economy observations has been established, this issue will be addressed again in further robustness checks. A similar case holds for Finland's economy.

4.2.5.3 Econometric foundations of the model: correlation and heteroskedasticity

Assumptions of no serial correlation and heteroskedasticity of idiosyncratic error make RE estimates best linear and unbiased. Validity of the assumptions has to be checked in more detail using diagnostic tests to make sure that results are reliable.

Serial correlation in panel data can take a number of forms. Presence of autocorrelation in panel data error terms has been confirmed earlier by the means of Wooldridge's test in the discussion of the pooled OLS estimates. Thus RE model with robust autoregressive residuals of order one is estimated, and the results are reported in Table 4-15. The estimated autocorrelation coefficient for the model appears to be close to unity, in particular 0.91. The introduction of autocorrelation robust standard errors into the model has diminished the coefficient of exchange rate volatility to 0.136, and the variable became insignificant in the unemployment formation, with the corresponding p value of 0.177. This novelty has not only reduced standard errors of the model, but also decreased the R squared values.

A modified Wald test is used to check for the group-wise heteroskedasticity in the residuals of the model. Here STATA uses residuals of the fixed effects to perform the test. This should give reliable results to indicate whether the issue of heteroskedasticity should be accounted for. Chi squared test statistic of 633.68 rejects the assumption of homoscedasticity of the error terms. This gives a clear foundation to run a regression with serial correlation and heteroskedasticity robust standard errors. RE model with heteroskedasticity and serial correlation robust standard errors is reported in Table 4-15.

It has been shown how serial correlation and heteroskedasticity affects regression results, even though the direction of the relationship between exchange rate volatility and unemployment rate has not changed, but its nature has. The effect became smaller in magnitude as well as lost its significance in both cases. With the coordinal change of regression outcomes, one would question the reliability of Hausman test results. Schaffer and Stillman (2010) created user written option "xtoverid" in STATA that can be used as an alternative for robust Hausman test. This option is a test of over-identifying restrictions with RE having two restrictions on the initial model. Test is ruled by the instrumental variables concept and results produce Sargan-Hansen statistic of 13.281. Its interpretation is highly dependent on benchmark critical level chosen for the analysis. Standard critical value for this work is 5% significance level. This critical value is very close to the test-estimated value of 0.0655. Here it has to be acknowledged that at 10% significance level FE model is preferred over alternatives, and at 5% significance level RE model will still be chosen.

However autoregressive serial correlation, as it has been noticed previously, can have many different forms – autoregressive (as it has been previously discussed), panel, or spatial. Further diagnostic tests are needed to identify the nature of serial correlation in the model. However panel techniques or STATA developed programs currently do not permit this. For example, let's consider the case where testing for autocorrelation in panel RE and FE models is needed. Panel data estimator with autocorrelation robust standard errors provided by STATA, has optional values of Baltagi and Wu (1999) statistic and Bhargava et. al. (1982) modified Durbin-Watson statistic that are reported alone without associated p values. Furthermore, corresponding research papers do not provide critical value tables for comparison, which unfortunately makes the values of test statistics of no use for the current research.

Table 4-16 Determinants of unemployment for OECD countries: sensitivity analysis

	Pooled OLS (clustered by country)	Fixed effects	Random effects	Random effects with AR1 disturbance in residuals	Random effects model robust to serial correlation and heteroskedasticity in residuals	Pooled OLS with Driscoll-Kraay standard errors	Fixed Effects with Driscoll-Kraay standard errors
Exchange rate volatility (EV1)	-0.426	0.511**	0.524**	0.136	0.524	-0.265	0.417
Output Gap	-0.509***	-0.526***	-0.536***	-0.329***	-0.536***	-0.496***	-0.510***
Tax Wedge	0.146**	0.137***	0.130***	0.030**	0.130***	0.155***	0.140***
Product Market Regulation	2.188	0.629*	0.657**	-0.062	0.657	0.687***	0.269
Employment Protection Legislation	-0.630	0.922*	0.440	-0.340	0.440	-0.438***	0.758
Average Benefit Replacement Rate	0.009	0.103***	0.088***	0.012	0.088***	0.013	0.103***
Union Density	-0.043	-0.021	-0.397*	0.053	-0.040	-0.049**	-0.016
Time effects	YES	YES	YES	YES	YES	NO	NO
Time dummies[1]						YES	YES
Standard error of Exchange Rate Volatility	0.852	0.223	0.221	0.101	0.413	0.353	0.287
R^2 within		0.599	0.597	0.510	0.597		
R^2 between		0.049	0.073	0.004	0.073		
R^2 overall	0.358	0.167	0.226	0.084	0.226		
Wooldridge test (2005)	118.296 (0.0000)						
Modified Wald test for heteroskedasticity		633.68 (0.000)					
Hausman test[2]		6.01 (0.539)	6.01 (0.539)		13.281[4] (0.0655)	3.35 [5] (0.017)	23.57 [5] (0.000)
Breusch-Pagan LM Test	3138.67 (0.000)		3138.67 (0.000)				
Average Number of Years[3]	24.1	24.1	24.1	24.1	24.1	24.1	24.1
Number of observations	482	482	482	482	482	482	482

Baseline specification: $\mathrm{Urt} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$, where Urt is ALFS Unemployment Rate
[1]Time dummies for years 1991, 2000 and 2008
[2] Hausman test results reported are based on regressions without time effects.
[3] Average number of years is used as panel is unbalanced
[4]Estimation of Hausman test has been done using Schaffer and Stillman (2010) written command "xtoverid" for STATA
[5]Wooldridge(2002) alternative to Hausman test has been estimated in STATA using the codes adapted from Hoechle(2007)
[6]Adapted Wooldridge (2002) test by Hoechle (2007) based on Driscoll-Kraay S.E. has been estimated in STATA using the codes adapted from Hoechle (2007)
* result is significant at 10% significance level
** result is significant at 5% significance level
*** result is significant at 1% significance level

Another econometric issue that is common in macroeconomics datasets is cross-sectional dependence. This arises due to a number of reasons. First of all, all countries in the data set are developed industrial countries with strong economic ties relative to other world countries. Secondly, some countries are not only similar in economic attributes, but have common geo location characteristics as well, implying there are neighbouring countries. Lastly, most of the countries (15 out of 20) in the dataset belong to European Union and currently are strongly economically integrated. So I believe it is a necessity to test model for cross-sectional dependence and remedy it if needed.

Three tests have been used for testing cross-sectional dependence in the sample. All of the tests are based on the RE model estimates and residuals, which has been chosen as the optimal so far. Please note that time effects are not included, because it is the between-groups correlation that is of interest, and additional variables only spur the results with contradictory conclusions. The Pesaran (2004) test for the null hypothesis of cross sectional independence produced statistic of 5.575 that gives foundations for the rejection of the null hypothesis. Accompanying absolute value of the off-diagonal elements of 0.321 indicates high cross-sectional correlation of the residuals. Additionally, Free's and Friedman's tests support the previous results of Pesaran test with corresponding test values of 3.953 (significance at 1% level) and 57.731 (p-value of 0.000). All of the statistics suggest the presence of cross-sectional dependence. One way to remedy for the cross-sectional dependence in the panel is to use Driscoll-Kraay standard errors. Contemporaneously they account not only for cross-sectional dependence, but also for heteroskedasticity and serial correlation. Pooled OLS and Fixed effects model have been both estimated with Driscoll-Kraay standard errors. Models draw contradictory conclusions on exchange rate volatility on unemployment rate, so, which one is the reliable one? Following Hoechle (2007) it has been decided to run two alternative tests to the Hausman test. The first one is based on Wooldridge (2002) auxiliary regression run with country's clustered residuals and is very similar to the over identifying restrictions Sargan test discussed earlier. Second version is essentially Wooldridge test adapted by Hoechle (2007), where auxiliary regression is run with Driscoll-Kraay residuals. Both results suggest that FE model should be chosen over the alternative pooled OLS method.

Once the appropriate model has been chosen it has been decided to re-run FE model with Driscoll and Kraay standard errors for all five volatility measures. The results are reported in Table 4-16. Exchange rate volatility significantly contributes to unemployment level formation for three volatility measures out of five. GARCH based volatility estimated coefficients are significant at the 5% significance level and increase in ERV of 1 % is associated with 0.145 percentage points increase in the unemployment rate. The effect of EV variables based on rolling standard deviation is much bigger in magnitude, but is less significant. Results are much less sensitive to country variation than previously thought, in particular to the inclusion of Swedish economy. If observations of Sweden are removed from the sample, coefficient of EV4 reduces from 0.140 to 0.121 with corresponding p value increase of 0.0047 to 0.082. Similarly for other volatility measures results became weaker, meaning partial loss of significance and magnitude, but do not vanish. In contrast to previous findings reported in Table 4-14, it should be noted that the direction of the relationship remains the same once correlations and heteroskedasticity have been addressed contemporaneously.

When the ALFS unemployment variable is substituted for the Harmonised Unemployment Rate, the result still holds for the GARCH based volatility measures at the 10% significance level. The magnitude is within the range here, and direction of the relationship is as predicted by ALFS unemployment rate based regressions, in contrast to previous studies.

The employment rate based regressions indicate that volatility increases the employment rate. However, these results are mostly insignificant and weakly supported only by rolling standard deviation measures of volatility based on 12 and 18 months lag length.

Activity rates, inactivity rates and structural unemployment variables are not affected by exchange rate volatility variations. The direction of the relationship of the variables with exchange rate volatility is as initially predicted in the Data Chapter.

Another significant link in EV relationship with labour market is Discouraged Workers indicator channel. Exchange rate volatility increases the number of discouraged workers. This result is supported by both GARCH and rolling standard deviation measures volatility. In magnitude ERV has bigger effect on discouraged labour force than on unemployment rates.

Table 4-17 Exchange rate volatility effect on labour market performance for OECD countries, using fixed effects with Driscoll-Kraay standard errors

Labour market performance indicator	Exchange rate volatility (EV1) (p-values)	Exchange rate volatility (EV2) (p-values)	Exchange rate volatility (EV3) (p-values)	Exchange rate volatility (EV4) (p-values)	Exchange rate volatility (EV5) (p-values)	Number of observations
Unemployment Rate	0.417 (0.162)	0.526* (0.095)	0.435 (0.156)	0.140** (0.047)	0.145** (0.015)	482

Unemployment Rate (excluding Sweden observations)[1]	0.192 (0.462)	0.266 (0.358)	0.215 (0.441)	0.121* (0.082)	0.072 (0.148)	456
Harmonised Unemployment Rate	0.283 (0.270)	0.423 (0.144)	0.334 (0.225)	0.111* (0.104)	0.108* (0.078)	440
Employment Rate	0.303 (0.115)	0.332* (0.092)	0.357* (0.058)	0.102 (0.272)	0.092 (0.137)	262
Activity Rate	0.157 (0.384)	0.236 (0.161)	0.205 (0.199)	0.065 (0.381)	0.048 (0.347)	262
Inactivity Rate	-0.162 (0.370)	-0.235 (0.166)	-0.206 (0.200)	-0.065 (0.384)	-0.048 (0.351)	262
Non-Accelerating Inflation Rate of Unemployment	0.244 (0.196)	0.263 (0.176)	0.232 (0.222)	0.055 (0.230)	0.069 (0.131)	462
Discouraged Workers	0.453 (0.117)	0.523* (0.093)	0.432* (0.075)	0.195 (0.120)	0.204* (0.101)	178

Baseline specification: $Y = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$, *where y is labour market performance indicator, estimated using FE model with Driscoll-Kraay standard errors.*

[1]Here Sweden's observations are excluded from the regression analysis

4.2.5.4 Baseline regression: error correction model

The stationarity of the series affects the regression outcomes and gives basis for long-run and short-run behavioural models. Before any models are to be estimated, stationarity of the series has to be established.

Unit root tests will be used for the assessment of series stationarity nature. Even though STATA offers a rich variety of panel unit root tests, the only one applicable in the unbalanced case is the Im-Pesaran-Shin (2003) test. Demeaned version has been used in the tests, and results are reported in Table 4-17.

Table 4-18. Im-Pesaran-Shin (2003) panel unit root tests with cross-sectional means removed

Variable	Z-t-tilde bar	P-value	Z-t-tilde bar for First Difference of the Variable	P-value for Z-t-tilde bar for First Difference of the Variable	Nature of the variable
Exchange rate volatility (EV1)	-11.7529	0.0000	-	-	I(1)
Exchange rate volatility (EV2)	-7.5458	0.0000	-	-	I(1)

Exchange rate volatility (EV3)	-9.2532	0.0000	-	-	I(1)
Exchange rate volatility (EV4)	-8.5565	0.0000	-	-	I(1)
Exchange rate volatility (EV5)	-10.3748	0.0000	-	-	I(1)
Unemployment Rate	0.3189	0.6251	-13.8286	0.0000	I(1)
Output Gap	-2.5537	0.0053	-	-	I(0)
Tax Wedge	-0.8470	0.1985	-13.0857	0.0000	I(1)
Product Market Regulation	2.7576	0.9971	-13.8474	0.0000	I(1)
Employment Protection Legislation	2.9996	0.9986	-11.5065	0.0000	I(1)
Average Benefit Replacement Rate	1.3056	0.9042	-10.7730	0.0000	I(1)
Union Density (UD)	0.0499	0.5199	-14.7132	0.0000	I(1)

H_0: All panels contain unit root, H_1: Some panels are stationary

Stationarity of the series has been established only for EV and Output gap variables. While output gap is an I(0) variable, EV variables are I(1), as during variable constructions they have been differenced to achieve stationarity. Similarly the rest of the variables are integrated of order one.

To account for omission variable bias and endogeneity, it has been decided to use heterogeneous panel estimator of Pesaran (2006) – Common Correlated Effects Mean Estimator. Its advantage lies in its robustness to common factors that could take non-stationary or even non-linear forms (Eberhardt (2012)). This is particularly beneficial in this case due to the fact that contemporaneously all of the variables of interest do not build a cointegrating relationship according to Westerlund (2007) tests. Most of the variables have been first differenced before inclusion in the regression for first differenced unemployment rate. The only variable that has not experienced any permutations is exchange rate volatility that has been differenced prior (i.e. during indicator construction). Results are reported in Table 4-18.

Table 4-19 Mean group estimators of unemployment determinants for OECD countries (1985-2011)

First differenced variables	Pesaran and Smith (1995) Mean Group Estimator, outlier robust (1)[1]	Pesaran and Smith (1995) Mean Group Estimator, outlier robust (2)[1]	Pesaran (2006) Common Correlated Effects Mean Group Estimator[3], outlier robust (1)	Pesaran (2006) Common Correlated Effects Mean Group Estimator, outlier robust (2)
Exchange Rate Volatility (EV1)	0.667***	0.598***	-0.164*	-0.222**
Tax Wedge	0.051**	0.0415*	-0.029	0.043***
Product Market Regulation	0.741	0.312	-0.580	-0.175
Employment Protection Legislation	-0.742	-0.948	0.516	-0.934
Average Benefit Replacement Rate	0.010	0.029	-0.076**	-0.044
Union Density	-0.487***	0.382***	0.146**	0.101
RMSE	0.7811	0.7511	0.3765	0.3566

[1](1) refers to model where dependent variable is first difference of unemployment rate indicator from ALFS

[2](2) refers to model where dependent variable is first difference of Harmonised Unemployment Rate,

[3] Results of averages for Pesaran (2006) model are not present in the table as are not essential for the discussion.

Exchange rate volatility is significant in all of the Mean Group estimators' regressions. According to Pesaran and Smith (1995) estimator there is a positive linear relationship between unemployment and exchange rate volatility. According to Pesaran (2006) relationship is negative linear, i.e. change in volatility is associated with the drop in unemployment rate change. Root mean square error statistic is the smaller in Pesaran (2006) models that could indicate it is a better quality. Adding the fact that Pesaran (2006) model is more robust to common factors, as has been previously discussed, it has to be concluded that in the short run, volatility has a negative effect on unemployment. This could be explained by the sticky wages, barriers to adjust labour costs instantly. Other reason than unemployment lagging could be arbitrage. Companies learn how to use it as an advantage and yield more revenues on it or those who do not know how to manage volatility risk hedge against it. So volatility of exchange rate creates a whole industry that sells different financial instruments to hedge against those risks.

Causality between unemployment rate and exchange rate is another issue that has to be addressed in sensitivity analysis. Following methodology of Bassanini and Duval (2009) and IMF (2014, pp.107-108), it has been decided to use Granger causality tests. In order to perform tests, series should be cointegrated. Variables of interest are integrated of order one, so here again first differenced variables are to be used for the purpose of the test. Westerlund (2007) four cointegration tests are used. All of statistics results reject null hypothesis of no cointegration. Taking into account that in small datasets results are sensitive to lag, lead length and kernel width, Westerlund (2007) tests have been re-estimated for variation of those. Results still are in support of rejecting null hypothesis of no cointegration. So to conclude there is cointegrating relationship between the two variables. This gives basis for Granger causality tests.

Table 4-20 Granger causality tests for exchange rate volatility and unemployment rate

	Dependent Variable is unemployment rate.	Dependent Variable is exchange rate volatility
Exchange Rate Volatility First Lag	0.195**	0.353***
Exchange Rate Volatility Second Lag	-0.048	0.099***
Unemployment Rate First Lag	0.525***	0.029*
Unemployment Rate Second Lag	-0.140***	0.002
Joint F-test	3.26	1.96
Probability > F	0.0389	0.1418
Number of observations	776	756

[1]All variables here, dependent and explanatory are in first differences.

First, number of lags has to be defined. Lag length of two has been chosen relying on auto regression t-test values. Next, unemployment rate and exchange rate determining regressions have been estimated using fixed effects model. Time dummies and country effects are included into regression analysis. Results are reported in Table 19.

According to results there is one Granger causal impact. Exchange rate volatility has causal impact on unemployment rate, but there is no reverse causality to it. So unemployment rate does not Granger cause exchange rate series. These results have to reject the hypothesis of endogeneity within the system that has been brought up here previously.

4.2.6 Conclusion

Initial results of the baseline random effects model suggest that there is a positive linear relationship among the exchange rate volatility and unemployment level. This relationship is significant for all standard deviation based volatility measures and asymmetric GARCH model. Additionally, it has been found that exchange rate volatility (based on standard deviation with lag length of 18 months) is positively associated with employment rates, activity rates, structural unemployment, and indicator of discouraged workers.

Model misspecification has been suspected and sensitivity analysis has been performed. Results have been robust to time and country effects variations. Once serial correlation, heteroskedasticity in the residuals and cross-sectional dependence have been addressed in the baseline model, results returned weaker than previously thought. Only for three out of five variables there has been found positive significant relationship among exchange rate volatility and the unemployment level. Once ALFS defined unemployment is substituted by the harmonised unemployment, the picture changes. Relationship holds exclusively for parametric models of exchange rate, but not for standard deviation based ones. Moreover, the exchange rate volatility is not associated with other labour performance indicators except for number of discouraged workers.

Mean group estimators have been used to account for omission variable bias. Pesaran (2006) estimator indicates that exchange rate volatility is inversely related to unemployment level (both HUR and ALFS). Causality has been addressed by the means of Granger causality tests. Results are suggestive of exchange rate volatility having Granger causal impact on unemployment. Furthermore no reverse causality has been found. Granger causality does not cover all the causality issues, and thus Granger tests alone are not sufficient to make conclusions on the causal relationships. Therefore, it is necessary to stress that results in this chapter represent simple correlation among variables, and should not be discussed in the context of causal impact.

Chapter 5. Inflation volatility effect on labour market performance

5.1 Derivation of inflation volatility measures

Similar to exchange rate series volatility, a number of inflation volatility models are estimated for the analysis. GARCH based measures and rolling standard deviation measures will be considered, as previously. However, there are expected differences in estimation. In particular distinct property of inflation series is long memory process that has be accounted for the volatility models chosen, so ARFIMA-GARCH models will be used (Cheung and Chung (2011)).

Before any tests are conducted, the data series have to be described in more detail. As has been discussed in the data and methodology chapter, quarterly GDP deflator series are employed for the purpose. Series have been tested for seasonality and no significant evidence has been detected to support the need to seasonally adjust the series. Furthermore, inflation series has been defined as percentage change in logarithm of GDP deflator series - 100dlog GDPdef.

5.1.1 Unit root tests

Autocorrelation function for inflation series has been estimated at different lag length up to an order of 36. Results are presented in Table 5-1. Autocorrelation function values are quite large in magnitude and do not die out geometrically with an increase in lag length, but rather vary randomly. Orderless behaviour has been noticed in the cases of the following countries – Austria, Germany, Finland, Ireland, Netherlands, Norway and New Zealand. In the case of Austria, the initial value of the function at lag length of 1 is very small (0.003), and this could be a signal of no correlation present in the series. Furthermore, Ljung-Box Q-statistics result (0.0015) and its associated p-value (0.000) support the hypothesis of no serial correlation at first order lag. This is an exceptional case of no serial correlation detected in the analysis, as for the rest of the series, Ljung-Box Q-statistics results have been evident of serial correlation in the series. Autocorrelation functions for Belgium and Switzerland look like a quadratic hyperbola that is steadily declining up to lags of 24 and 20 respectively, after which they grow in value. The remainder of the series have an overall declining trend. However, high persistence in the series is very noticeable as function values decline very slowly with lag length increase. Autocorrelation coefficient for some series varies not only in value but also in direction. This is the case for autocorrelation functions for Germany, Ireland, Norway and New Zealand. Autocorrelation function observations together with the Q-statistics results indicate that series are non-stationary and persistent to a high order.

Appropriate unit root tests need to be carried out to establish the time series nature of the data. Starting with Augmented Dickey Fuller Test where only constant exogenous variable is assumed in structural equation. Test results of all applicable unit root tests are reported in Table 5-2. Only for 12 out of 20 series do ADF test results provide unambiguous answers on the nature of the series, for the rest of the series the answer varied dramatically depending on the significance level. Such inconclusive results have been reached for inflation series of Australia, Switzerland, Finland, Ireland, New Zealand, United Kingdom and the United States. Further non-parametric tests of Philips-Perron (PP) are conducted based on similar assumptions of ADF tests. This test is an improved version of ADF test where t-statistic does not suffer from serial correlation bias. As has been underlined in the analysis of autocorrelation functions for the series, one would expect PP tests to be a more appropriate unit root test. ADF test results have been supported by PP tests only for Germany, Ireland, Japan, Norway and Portugal. Previous inconclusive results has been improved in their sensitivity to significance level, this applies to series of Australia, Switzerland, Finland, New Zealand and UK, which appear to be stationary in their nature. The US series test results have not been clarified by PP tests and still results are sensitive to significance level.

However PP tests gave co-ordinally opposite results from ADF tests in cases such as Austria, Canada, Denmark, France, Italy, Netherlands, Sweden and the US. Robustness of ADF tests results to significance level for Belgium and Spain have been distorted, creating inconclusiveness in determination of stationarity. Both of the tests used so far have common formulation of null and alternative hypothesis. A good alternative to potentially minimise Type I and Type II errors in the results would be to use a test that has inverse formulation of the null hypothesis. For this purpose Kwiatkowski – Phillips – Schmidt – Shin (KPSS) tests were chosen. Tests were run under similar conditions to previous ones, i.e. assuming constant exogenous variable in structural equation. Test results have not brought clarity to the main question of whether the series contain unit roots or not. They have brought mixed results based on sensitivity to significance level and determined outcomes in many cases are opposing what PP tests have derived. Only in the case of inflation series for Norway, may we suggest that stationarity of the series has been confirmed by all of the tests that have been run and robustness of the result to significance level has been established.

Table 5-1 Autocorrelation function of inflation series

Lag	AT	AU	BE	CA	CH	DE	DK	ES	FI	FR	IE	IT	JP	NL	NO	NZ	PT	SE	UK	US
1	0.003	0.55	0.859	0.681	0.815	0.393	0.568	0.909	0.383	0.784	-0.093	0.685	0.721	0.329	0.288	-0.133	0.936	0.843	0.601	0.888
2	0.318	0.519	0.831	0.543	0.741	0.402	0.727	0.878	0.451	0.782	0.165	0.678	0.678	0.325	-0.016	-0.293	0.906	0.824	0.609	0.843
3	0.202	0.461	0.739	0.502	0.623	0.405	0.565	0.841	0.376	0.691	0.153	0.619	0.579	0.309	0.073	0.380	0.849	0.764	0.635	0.814
4	0.338	0.474	0.685	0.444	0.585	0.410	0.684	0.808	0.502	0.718	0.200	0.710	0.562	0.439	0.082	-0.101	0.832	0.714	0.513	0.785
5	0.286	0.452	0.638	0.529	0.511	0.258	0.502	0.805	0.308	0.740	0.087	0.600	0.500	0.428	-0.021	0.033	0.801	0.674	0.485	0.721
6	0.32	0.431	0.605	0.487	0.462	0.220	0.670	0.786	0.304	0.718	0.089	0.600	0.520	0.366	0.005	0.313	0.803	0.631	0.458	0.683
7	0.191	0.379	0.56	0.436	0.441	0.193	0.522	0.766	0.331	0.703	0.265	0.562	0.517	0.341	-0.012	-0.075	0.783	0.629	0.437	0.634
8	0.176	0.366	0.547	0.396	0.438	0.234	0.644	0.736	0.372	0.655	-0.105	0.606	0.455	0.319	0.008	0.015	0.792	0.600	0.400	0.612
9	0.42	0.398	0.482	0.314	0.390	0.154	0.520	0.706	0.355	0.639	0.209	0.561	0.490	0.336	0.067	0.127	0.765	0.585	0.426	0.576
10	0.114	0.39	0.487	0.335	0.353	0.062	0.651	0.682	0.316	0.624	0.121	0.536	0.443	0.309	0.051	0.003	0.750	0.565	0.388	0.552
11	0.232	0.324	0.424	0.376	0.293	0.143	0.424	0.664	0.268	0.598	0.007	0.540	0.513	0.229	-0.013	0.120	0.730	0.552	0.399	0.531
12	0.183	0.311	0.418	0.308	0.316	0.080	0.538	0.645	0.310	0.598	0.017	0.546	0.468	0.315	0.035	-0.070	0.718	0.526	0.366	0.524
13	0.275	0.285	0.379	0.296	0.265	0.030	0.468	0.627	0.305	0.555	0.143	0.537	0.534	0.307	0.016	0.037	0.686	0.512	0.339	0.509
14	0.198	0.301	0.351	0.306	0.272	0.078	0.469	0.600	0.179	0.602	0.024	0.479	0.439	0.297	0.052	0.275	0.657	0.519	0.356	0.496
15	0.249	0.277	0.327	0.27	0.252	-0.017	0.463	0.576	0.299	0.555	-0.042	0.491	0.474	0.237	0.102	-0.002	0.619	0.492	0.315	0.481
16	0.049	0.177	0.313	0.268	0.245	-0.020	0.460	0.556	0.248	0.542	0.128	0.451	0.408	0.232	0.128	-0.122	0.601	0.509	0.362	0.468
17	0.26	0.253	0.275	0.300	0.191	-0.001	0.460	0.531	0.321	0.516	0.027	0.408	0.422	0.224	-0.017	0.160	0.585	0.513	0.362	0.455
18	0.274	0.28	0.308	0.274	0.134	-0.107	0.451	0.497	0.176	0.511	0.069	0.383	0.431	0.229	-0.091	0.031	0.574	0.494	0.392	0.434
19	0.087	0.262	0.283	0.283	0.086	-0.169	0.444	0.478	0.235	0.529	0.062	0.401	0.352	0.233	0.032	-0.004	0.552	0.528	0.393	0.414
20	0.182	0.194	0.294	0.266	0.065	-0.12	0.429	0.441	0.297	0.506	0.05	0.412	0.321	0.258	0.094	0.254	0.547	0.495	0.33	0.406
21	0.04	0.231	0.274	0.28	0.091	-0.022	0.414	0.418	0.229	0.519	0.062	0.395	0.308	0.195	0.131	-0.054	0.539	0.512	0.377	0.377
22	0.269	0.194	0.252	0.29	0.118	-0.109	0.402	0.395	0.226	0.472	-0.113	0.362	0.403	0.227	0.063	-0.072	0.528	0.475	0.266	0.365
23	0.132	0.234	0.239	0.274	0.158	-0.066	0.415	0.381	0.257	0.485	0.121	0.349	0.34	0.17	0.082	0.163	0.518	0.461	0.27	0.381
24	0.148	0.26	0.232	0.275	0.185	-0.085	0.353	0.369	0.358	0.435	-0.086	0.374	0.419	0.261	0.093	0.011	0.505	0.437	0.235	0.357
25	0.107	0.204	0.24	0.268	0.206	-0.069	0.422	0.348	0.313	0.461	-0.02	0.325	0.376	0.177	0.05	-0.034	0.482	0.419	0.19	0.331
26	0.128	0.195	0.274	0.256	0.22	-0.063	0.363	0.338	0.262	0.415	-0.069	0.307	0.382	0.158	-0.085	0.133	0.438	0.405	0.128	0.302
27	0.131	0.191	0.274	0.255	0.247	-0.167	0.376	0.312	0.311	0.409	0.041	0.28	0.339	0.135	-0.011	0.056	0.403	0.365	0.149	0.288
28	0.198	0.203	0.317	0.301	0.258	-0.097	0.339	0.308	0.277	0.386	-0.081	0.283	0.338	0.178	0.148	-0.041	0.374	0.367	0.104	0.262
29	0.15	0.157	0.309	0.337	0.248	-0.167	0.36	0.293	0.238	0.357	-0.157	0.272	0.306	0.184	0.04	0.04	0.374	0.352	0.074	0.233
30	0.092	0.112	0.32	0.278	0.244	-0.107	0.332	0.289	0.18	0.339	0.054	0.19	0.29	0.175	-0.022	0.068	0.362	0.351	0.084	0.196
31	0.189	0.178	0.307	0.232	0.25	-0.129	0.313	0.281	0.233	0.295	-0.135	0.185	0.318	0.117	0.073	0.047	0.359	0.348	0.061	0.17
32	0.135	0.118	0.311	0.19	0.243	-0.144	0.301	0.257	0.219	0.279	-0.121	0.172	0.246	0.123	0.143	-0.056	0.344	0.335	0.078	0.162
33	0.134	0.106	0.309	0.169	0.25	-0.128	0.267	0.252	0.194	0.257	0.028	0.182	0.272	0.103	-0.042	0.052	0.324	0.339	0.052	0.146
34	0.127	0.077	0.301	0.129	0.259	-0.036	0.26	0.244	0.19	0.229	-0.061	0.123	0.215	0.051	-0.061	0.118	0.285	0.287	0.086	0.113
35	0.172	0.039	0.277	0.108	0.297	-0.071	0.248	0.241	0.165	0.214	-0.088	0.117	0.246	0.132	-0.031	-0.02	0.255	0.294	0.021	0.094
36	0.155	0.01	0.283	0.122	0.293	-0.135	0.224	0.23	0.194	0.163	-0.005	0.08	0.23	0.14	-0.082	0.032	0.22	0.268	0.065	0.106

Autocorrelation function values have been derived using EViews 8.0, where lag refers to function's lag length. Inflation series represent 100dlogGDPdef.

Regarding the rest of the series - a mixed picture has been drawn. One may conclude that results are evident of series being non-stationary as has been observed not only from test results, but also from level correlogram of the series. On the other side, evidence of series containing unit root has been mixed and not that powerful. For additional checks of non-stationarity, it has been decided to build autocorrelation function of the first difference of the series to see whether differencing had eliminated serial correlation. Results are presented in Table 5-3.

Table 5-2 Unit root tests' results for inflation series

	Significance Level	ADF		PP		KPSS		Result
		Statistic value	No. of unit roots	Statistic value	No. of unit roots	Statistic value	No. of unit roots	
Austria	1%, 5%, 10%	-1.863274	1	-17.17632	0	1.231859	1	0/1
Australia	1% 5% 10%	-3.189469	1 0 0	-8.978099	0	0.524183	0 1 1	0/1
Belgium	1% 5% 10%	-2.473809	1	-3.421039	0 1 1	0.750625	1	0/1
Canada	1% 5% 10%	-2.543089	1	-5.980422	0	0.64768	0 1 1	0/1
Switzerland	1% 5% 10%	-3.293803	1 0 0	-4.153002	0	1.137816	1	0/1
Germany	1% 5% 10%	-7.512849	0	-7.507719	0	0.407459	0 0 1	0/1
Denmark	1%, 5%, 10%	-1.445584	1	-9.144467	0	1.233846	1	0/1
Spain	1% 5% 10%	-1.982914	1	-2.847562	1 1 0	0.867405	1	0/1
Finland	1% 5% 10%	-2.920647	1 0 0	-12.08613	0	1.0651	1	0/1
France	1%, 5%, 10%	-1.468602	1	-4.339996	0	0.875282	1	0/1
Ireland	1% 5% 10%	-10.4917	0	-10.61139	0	0.56568	0 1 1	0/1
Italy	1% 5% 10%	-1.944434	1	-7.265825	0	0.681034	0 1 1	0/1
Japan	1%, 5%, 10%	-3.880802	0	-5.971401	0	1.492616	1	0/1
Netherlands	1%, 5%, 10%	-2.381693	1	-12.47156	0	1.063249	1	0/1
Norway	1%, 5%, 10%	-10.83312	0	-10.78879	0	0.309839	0	0
New Zealand	1% 5% 10%	-3.298388	1 0 0	-16.867	0	0.548175	0 1 1	0/1
Portugal	1% 5% 10%	-1.685197	1	-2.31602	1	0.536901	0 1 1	0/1
Sweden	1%, 5%, 10%	-2.553063	1	-3.668251	0	0.896461	1	0/1
United Kingdom	1% 5% 10%	-2.860617	0 1 1	-8.289685	0	0.648538	0 1 1	0/1
United States	1% 5% 10%	-2.600206	1 1 0	-3.203328	1 0 0	0.571701	0 1 1	0/1

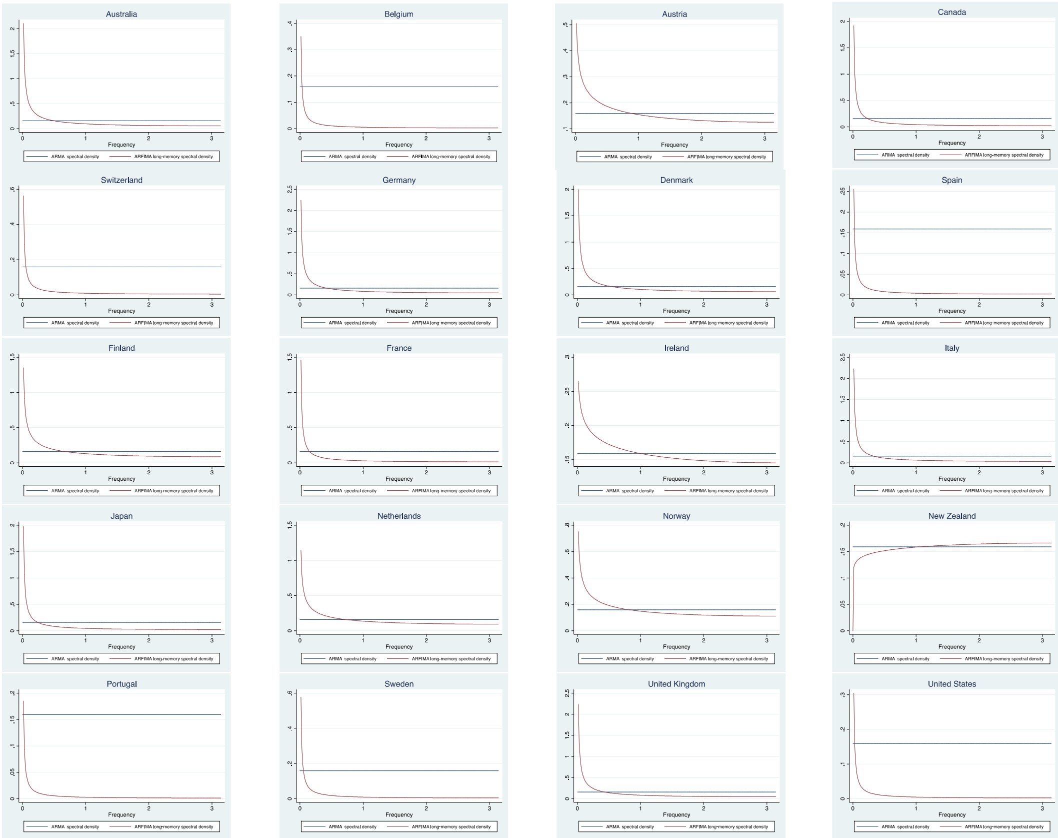
Unit root test statistics have been estimated using Eviews 8.0. In cells where only one result being represented against different significance level implies that this is unique result for all significance levels.

All tests have been run assuming that constant is exogenous, and inflation series are 100dlogGDPdef

Table 5-3 Autocorrelation function of first difference of inflation series

Lag	AT	AU	BE	CA	CH	DE	DK	ES	FI	FR	IE	IT	JP	NL	NO	NZ	PT	SE	UK	US
1	-0.659	-0.464	-0.413	-0.284	-0.304	-0.442	-0.688	-0.358	-0.558	-0.506	-0.616	-0.491	-0.428	-0.491	-0.286	-0.43	-0.246	-0.436	-0.509	-0.307
2	0.218	0.028	0.261	-0.16	0.111	-0.073	0.376	0.027	0.12	0.212	0.127	0.081	0.104	0.005	-0.277	-0.368	0.195	0.124	-0.025	-0.081
3	-0.129	-0.075	-0.153	0.032	-0.207	0.062	-0.325	0.011	-0.163	-0.27	-0.033	-0.236	-0.154	-0.111	0.056	0.509	-0.312	-0.031	0.187	0.002
4	0.097	0.04	-0.026	-0.227	0.092	0.128	0.348	-0.197	0.263	0.005	0.08	0.322	0.085	0.112	0.079	-0.27	0.107	-0.028	-0.114	0.165
5	-0.045	-0.006	-0.053	0.202	-0.06	-0.091	-0.406	0.111	-0.156	0.115	-0.056	-0.183	-0.148	0.029	-0.092	-0.065	-0.271	-0.011	-0.008	-0.121
6	0.082	0.04	0.042	0.009	-0.09	0.012	0.372	0.002	-0.025	-0.021	-0.077	0.067	0.037	-0.025	0.03	0.295	0.117	-0.113	-0.003	0.054
7	-0.058	-0.046	-0.086	-0.01	-0.038	-0.076	-0.315	0.064	-0.012	0.083	0.25	-0.128	0.112	0.004	-0.024	-0.211	-0.216	0.085	0.019	-0.112
8	-0.13	-0.052	0.165	0.07	0.113	0.073	0.287	0.014	0.045	-0.077	-0.317	0.146	-0.17	-0.036	-0.027	-0.01	0.294	-0.051	-0.081	0.038
9	0.277	0.046	-0.255	-0.166	-0.025	0.107	-0.304	-0.048	0.017	-0.01	0.185	-0.035	0.149	0.035	0.05	0.104	-0.061	0.018	0.083	-0.043
10	-0.214	0.063	0.259	-0.029	0.068	-0.11	0.421	-0.018	0.009	0.032	0.014	-0.045	-0.214	0.037	0.036	-0.107	0.014	-0.022	-0.063	-0.01
11	0.084	-0.057	-0.208	0.174	-0.219	-0.006	-0.399	0.007	-0.07	-0.065	-0.038	0.004	0.202	-0.106	-0.08	0.136	-0.034	0.045	0.058	-0.063
12	-0.071	0.012	0.125	-0.09	0.209	0.102	0.22	-0.009	0.039	0.117	-0.087	0.016	-0.203	0.04	0.048	-0.132	0.149	-0.028	-0.01	0.032
13	0.085	-0.047	-0.022	-0.039	-0.166	-0.096	-0.086	0.052	0.098	-0.225	0.123	0.073	0.294	0.017	-0.039	-0.057	0.01	-0.076	-0.055	-0.016
14	-0.065	0.05	0.004	0.07	0.045	0.121	0.021	-0.019	-0.202	0.216	-0.021	-0.103	-0.234	0.043	-0.009	0.227	0.025	0.09	0.072	0.038
15	0.126	0.08	-0.062	-0.052	0.018	-0.103	-0.002	-0.029	0.14	-0.076	-0.107	0.078	0.185	-0.034	0.016	-0.07	-0.154	-0.117	-0.108	-0.033
16	-0.206	-0.195	0.066	-0.04	0.093	-0.057	-0.009	0.037	-0.102	0.025	0.117	0.005	-0.15	-0.005	0.12	-0.177	-0.003	0.026	0.058	-0.006
17	0.098	0.05	-0.23	0.085	0.016	0.193	0.014	0.049	0.174	-0.043	-0.062	-0.033	0.013	-0.019	-0.049	0.182	-0.051	0.076	-0.038	0.036
18	0.101	0.048	0.189	-0.058	-0.063	-0.033	-0.019	-0.084	-0.168	-0.06	0.023	-0.061	0.157	0.005	-0.138	-0.042	0.094	-0.173	0.035	-0.006
19	-0.142	0.057	-0.121	0.021	-0.057	-0.104	0.002	0.114	0.004	0.097	-0.01	0.01	-0.089	-0.025	0.035	-0.129	-0.121	0.218	0.08	-0.04
20	0.118	-0.113	0.108	-0.056	-0.115	-0.026	0.012	-0.082	0.103	-0.082	0.006	0.038	-0.022	0.085	0.021	0.25	0.003	-0.136	-0.136	0.092
21	-0.186	0.086	0.03	0.031	-0.004	0.17	0.01	0.005	-0.051	0.14	0.086	0.024	-0.201	-0.076	0.079	-0.129	0.048	0.161	0.196	-0.07
22	0.185	-0.089	-0.042	0.054	-0.043	-0.165	-0.037	-0.043	-0.028	-0.142	-0.197	-0.022	0.294	0.061	-0.06	-0.111	-0.011	-0.084	-0.143	-0.124
23	-0.078	0.014	-0.023	-0.025	0.017	0.094	0.092	-0.024	-0.058	0.157	0.195	-0.072	-0.27	-0.101	0.006	0.171	0.026	0.044	0.05	0.191
24	0.03	0.092	-0.073	0.01	0.024	-0.004	-0.152	0.071	0.117	-0.179	-0.111	0.124	0.22	0.118	0.038	-0.047	0.091	-0.007	0.011	0.005
25	-0.033	-0.056	-0.101	-0.006	0.016	-0.04	0.147	-0.076	0.006	0.163	0.045	-0.049	-0.083	-0.05	0.061	-0.093	0.175	-0.049	0.02	0.022
26	0.01	-0.006	0.128	-0.012	-0.031	0.118	-0.086	0.107	-0.083	-0.088	-0.063	0.014	0.091	0.011	-0.146	0.107	-0.074	0.103	-0.103	-0.072
27	-0.032	-0.011	-0.134	-0.066	0.038	-0.143	0.067	-0.126	0.071	0.035	0.107	-0.047	-0.082	-0.054	-0.062	0.01	-0.046	-0.125	0.083	0.058
28	0.057	0.06	0.17	0.004	0.056	0.053	-0.087	0.053	0.007	0.015	-0.026	0.022	0.063	0.033	0.188	-0.078	-0.264	0.049	-0.019	-0.001
29	0.006	0.005	-0.074	0.15	-0.01	-0.077	0.074	-0.059	0.017	-0.021	-0.12	0.107	-0.035	0.01	-0.031	0.02	0.11	-0.06	-0.049	0.058
30	-0.079	-0.13	0.079	-0.017	-0.02	0.069	-0.014	0.01	-0.092	0.048	0.185	-0.119	-0.082	0.028	-0.111	0.024	-0.098	0.011	0.04	-0.043
31	0.076	0.137	-0.065	-0.009	0.03	0.053	-0.007	0.096	0.056	-0.061	-0.102	0.009	0.184	-0.039	0.021	0.036	0.088	0.043	-0.05	-0.081
32	-0.027	-0.042	0.057	-0.032	-0.037	-0.093	0.026	-0.109	0.006	0.026	-0.06	-0.03	-0.173	0.013	0.178	-0.095	0.071	-0.06	0.053	0.035
33	0.003	0.01	0.01	0.035	-0.01	-0.038	-0.029	0.015	-0.019	0.02	0.102	0.104	0.144	0.027	-0.117	0.024	0.188	0.179	-0.076	0.081
34	-0.027	0.009	0.062	-0.034	-0.08	0.126	0.003	-0.029	0.015	-0.035	-0.017	-0.083	-0.159	-0.099	-0.035	0.087	-0.082	-0.191	0.123	-0.057
35	0.033	-0.01	-0.106	-0.053	0.108	0.077	0.017	0.041	-0.045	0.091	-0.06	0.055	0.093	0.064	0.054	-0.088	0.051	0.102	-0.136	-0.151
36	-0.008	-0.052	0.164	0.154	-0.011	-0.246	0.007	0.066	0.04	-0.193	0.054	-0.088	-0.101	0.041	-0.09	-0.001	-0.03	-0.033	0.02	0.124

Diagram 1 Long-run spectral densities of ARMA (0,0) and ARFIMA (0,d,0) models



Common property of autocorrelation functions for all of the series first differences is that it starts with a large negative value at lag one. This could be evidence of series being over differenced, as a result of misleadingly assuming series containing one unit root when they do not. Further, Bailie et. al. (1996) conclude that if KPSS and PP tests give contradicting results, based on rejecting null hypothesis in both tests, this would be evident of some process that is not well described by either I(0) nor I(1). Further one could assume that series are fractionally integrated.

Spectral density analysis compares long run ARFIMA model fitting to analogous ARMA model fitting, results are plotted in diagram 1. Please note, that we have compared values of spectral density only in the long run. Short-run results are not reported here as for both ARMA and ARFIMA, spectral density function is the same, because autoregressive and moving average parts have not been included in specifications.

From the graphs in Diagram 1, it can be observed that in long run ARFIMA model is a better fit for inflation series, as it better describes long memory process. In fractionally integrated model historical values effect is decaying exponentially rather than being linearly carried forward, as being described by the flat spectral density plot implied by

ARMA model. For most of the series we expect difference parameter d to be positive as spectral density function diverges to infinity when d approaches zero value. However, the case of New Zealand is a standout from the diagram due to its spectral density function appearing as inverted exponential line in contrast to the rest. Its value is converging to zero when d approaches zero – it is the case when d parameter is negative. The estimation of parameter d is different to the usual ARIMA estimation steps. In fractionally integrated models parameter d is derived simultaneously with autoregressive and moving average parts (Doornik and Ooms (2004)). So for different combination of ARMA terms there will be different d parameters, thus further d estimation analysis is carried out in appropriate model estimation sub-sections. Parameter derivation procedure by default is based on the iterative methods of Maximum Likelihood. Robustness of the results obtained from ML, where possible has been confirmed by the maximum modified profile likelihood function (MPL). MPL technique is advanced to the default ML instrument and is used for exogenous bias correction.

5.1.2 Rolling standard deviation model of inflation volatility

For rolling standard deviation model ARFIMA(0,d,0) model will be used. In table 5-4 estimation results for parameter d are present. For most of the series parameter values lay within the open interval of 0 to 0.5. Its corresponding p values of 0.000 indicate that d parameter explains a long-run variation in the series. However this is not true for all series.

Maximum likelihood estimation has derived a relatively small d parameter value for the Ireland's inflation series. Validity of the finding is very doubtful and is rejected at 1%, 5% and 10% significance level. ARFIMA modelling is unsuitable here so we have to establish whether series are stationary or non-stationary. For additional stationarity tests ARFIMA modelling is used. Further d estimation procedure using both ML and MPL consequently on differenced Ireland's inflation series has yielded similar result of d parameter approaching the limit of -1. This is evident that if differencing of the series will yield an unpleasant result of "over differencing", implying that initial series are stationary. This is in line with the unit root KPSS and PP test results.

Table 5-4 Parameter d results obtained by iterative methods for ARFIMA (0,d,0) model

Country		Maximum Likelihood		Modified-Profile-Likelihood		D value*
		d	p	d	p	
Austria	AT	0.142	0.000	0.149	0.000	0.149

Australia	AU	0.369	0.000	0.387	0.000	0.387
Belgium	BE	0.495	0.000	-	-	0.495
Canada	CA	0.452	0.000	-	-	0.452
Switzerland	CH	0.491	0.000	-	-	0.491
Germany	DE	0.393	0.000	0.450	0.000	0.450
Denmark	DK	0.354	0.000	0.367	0.000	0.367
Spain	ES	0.496	0.000	-	-	0.496
Finland	FI	0.280	0.000	0.292	0.000	0.292
France	FR	0.470	0.000	-	-	0.470
Ireland	IE	0.061	0.358	0.082	0.247	0
Italy	IT	0.425	0.000	0.446	0.000	0.446
Japan	JP	0.449	0.000	0.482	0.000	0.482
Netherlands	NL	0.254	0.000	0.265	0.000	0.265
Norway	NO	0.194	0.001	0.217	0.001	0.217
New Zealand	NZ	-0.033	0.432	-0.024	0.579	0
Portugal	PT	0.497	0.000	-	-	0.497
Sweden	SE	0.491	0.000	-	-	0.491
United Kingdom	UK	0.392	0.000	0.410	0.000	0.410
United States	US	0.495	0.000	-	-	0.495

d values together with its corresponding p values have been derived using STATA 13 software.

* D value in the final column is the values that we assume and carry forward for the further analysis, where it is equal 0 we assume that series are stationary, where possible we prefer d value that has been derived by MPL technique as it is less bias.

As expected New Zealand's inflation difference parameter appeared to be negative in the region of 0 to -0.5. This result is hard to interpret, but its interpretation is not the aim of this research as the result is highly insignificant with the corresponding p value of 0.579. ARFIMA model is not an adequate measure of description for the Netherlands inflation processes. Similar to the previous case ARFIMA iterative estimation method for differenced inflation series is used to determine stationarity of the series. Here difference parameter is approaching -1 value that is evident of series being over differenced. This result comes in line with the large negative ACF value of -0.43 at lag 1 of first difference of the series. Combining these results with previous unit root tests' results, stationarity of the series becomes evident.

Next rolling standard deviation of the series is derived. For New Zealand and Ireland primary data is used. For the rest of the countries prior to any transformations inflation series will be fractionally differenced using applicable d parameter (Table 5-4). This is achieved in STATA 13 using "fracdiff" command. In the cases, where it is possible to do so, fractional difference parameter derived by MPL is used, where there is no such a possibility, d parameter derived by default ML technique is used. Then rolling standard deviation of the series is estimated by assuming optimal lag length of 4, since the series are of quarterly frequency. Statistical properties of the series are described in the next section together with the rest of the measures.

5.1.3 GARCH based measures of inflation volatility

Following Bailie et. al. (1996), it has been decided that ARFIMA (0,d, 1) - GARCH (1,1) model is to be fitted for the parametric modelling of the inflation series. One of the reasons is that fractionally integrated models better describe series in both short-run and long-run in contrast to analogous ARMA and ARIMA models. Diagram 2 illustrates these differences in model estimates, where top graph depicts spectral densities of ARMA and ARFIMA long run parameters, and bottom diagram depicts the short run dynamics.

Looking at the top graph for all countries, one common feature arises. All graphs are evident of difference parameter d being positive, as there is no inverted curve for ARFIMA long-run spectral density. This result is in contrast to previous study of spectral density functions depicted in Diagram 1, where for New Zealand ARFIMA(0,d,0) model, the graph was of inverted shape in relation to others. Here for all of the inflation series spectral density functions are approaching infinity once frequency approaches zero value. For most of the series ARFIMA spectral density function resembles hyperbolic shape with minor adjustments in cases of Ireland, Norway and New Zealand.

Ireland inflation's spectral density values derived by ARMA and ARFIMA parameters diverge at the end, where frequency decreases to zero. At the opposite end, where frequency values aim to reach infinity, both spectral densities graphs diverge to unique value that is steadily increasing after frequency value of two. New Zealand's spectral density's graph behaviour in the long run is very similar to that of Ireland's. The only difference is that the rate of change is higher after the density function reaches its minimal value. Please note, comparing ARFIMA (0,d,1) to ARFIMA (0,d,0) models for New Zealand, addition of moving average part removed changed the difference parameter to a positive value.

Norway's spectral density functions' graphs for both long run and short run are almost identical. The only difference is that ARMA spectral density function's value at 0 is finite and for ARFIMA models it is in the limit approaching infinity, so there is no fixed value. As parameters for both models draw a very similar behavioural picture for the series then there is a question arising if ARFIMA model is a better fit for the series? As from the glance on the graph, it looks as if moving average part describes the majority of the variation in the series.

Diagram 2 Long-run spectral densities of ARMA(0,1) and ARFIMA(0,d,1) models

ARFIMA (0,d,1) is being fitted to the inflation series using Maximum Likelihood Iteration method in STATA 13.0. Only for Canada and Norway inflation series it was possible to use alternative MPL procedure. For the rest of the series Broyden – Fletcher – Goldfarb - Shanno stepping becomes contracted and iteration technique does not converge. Difference parameter has been estimated by default technique, where possible it has been substituted by a less biased one, derived using the MPL method.

Observations of spectral density graphs for Norway have been confirmed by the ARFIMA modelling. It appeared that d parameter is highly insignificant and that moving average part accounts for the series in time dynamics. Its impact on the series is comparatively large with coefficient value of 0.327 and highly significant (corresponding p value of 0.000). So all of the analysis are confirming the hypothesis that ARFIMA modelling is not the best fit for the Norway inflation series model, the only remaining question to answer is what model is better fit ARIMA (0,1,1) or ARMA (0,1)? ARFIMA modelling of differenced Norway series can help us here to define the stationarity of the series. Fractional difference parameter approaching limit of -1 is indicative of series being over differenced and not suitability of ARIMA (0,1,1) for series modelling. This is in line with all the unit root tests where Norway inflation series appeared to be stationary.

Table 5-5 Parameter d results obtained by iterative methods for ARFIMA (0,d,1) model

Country		Maximum Likelihood		Modified-Profile-Likelihood		D value*
		d	p	d	p	
Austria	AT	0.462	0.000	-	-	0.462
Australia	AU	0.449	0.000	-	-	0.449
Belgium	BE	0.492	0.000	-	-	0.492
Canada	CA	0.402	0.000	0.454	0.000	0.454
Switzerland	CH	0.482	0.000	-	-	0.482
Germany	DE	0.466	0.000	-	-	0.466
Denmark	DK	0.484	0.000	-	-	0.484
Spain	ES	0.494	0.000	-	-	0.494
Finland	FI	0.451	0.000	-	-	0.451
France	FR	0.487	0.000	-	-	0.487
Ireland	IE	0.360	0.004	-	-	0.360
Italy	IT	0.483	0.000	-	-	0.483
Japan	JP	0.463	0.000	-	-	0.463
Netherlands	NL	0.467	0.000	-	-	0.467
Norway	NO	0.019	0.777	0.039	0.577	0
New Zealand	NZ	0.417	0.000	-	-	0.417
Portugal	PT	0.495	0.000	-	-	0.495
Sweden	SE	0.489	0.000	-	-	0.489

United Kingdom	UK	0.477	0.000	-	-	0.477
United States	US	0.491	0.000	-	-	0.491

d values together with its corresponding p values have been derived using STATA 13 software.

* D value in the final column is the values that we assume and carry forward for the further analysis, where it is equal 0 we assume that series are stationary, where possible we prefer d value that has been derived by MPL technique as it is less bias.

Concluding from the ARFIMA estimation analysis, for all the countries inflation series fractionally integrated moving average is a better-fit model. The only exception is Norway inflation series where ARMA (0,1,) gives a better approximation.

Second step is fitting parametric model GARCH(1,1) to the series. Before any fittings will be done Lagrange Multiplier residual test for the presence of ARCH effects will be run. Lag length for the series is defined at 1, 6 and 12 in order to capture autoregressive conditional heteroskedasticity at different levels. Tests results are reported in Table 5-6.

Table 5-6 ARCH LM test results for ARFIMA (0,d,1) specification

	K=1			K=6			K=12		
	F stat	TR^2	Presence of ARCH effects	F stat	TR^2	Presence of ARCH effects	F stat	TR^2	Presence of ARCH effects
AT	28.31	25.05	YES	14.24	61.11	YES	9.65	75.26	YES
AU	70.36	52.57	YES	13.75	59.65	YES	6.95	60.96	YES
BE	38.51	32.62	YES	8.36	41.13	YES	5.49	51.61	YES
CA	1.34	1.34	NO	0.56	3.41	NO	0.34	4.26	NO
CH	42.62	34.84	YES	16.60	65.39	YES	2.70	29.07	YES
DE	0.04	0.04	NO	0.31	2.03	NO	0.43	5.90	NO
DK	8.48	8.18	YES	5.10	26.92	YES	3.34	34.52	YES
ES	13.58	12.85	YES	7.92	39.41	YES	3.77	38.74	YES
FI	40.19	33.80	YES	13.40	58.56	YES	8.00	66.91	YES
FR	12.77	12.13	YES	7.33	37.03	YES	4.28	42.80	YES
GB	11.98	11.42	YES	5.85	30.72	YES	3.19	33.80	YES
IE	0.27	0.27	NO	0.24	1.55	NO	0.38	5.20	NO
IT	6.42	6.28	YES	2.78	15.88	YES	3.41	35.68	YES
JP	27.98	24.79	YES	9.22	44.42	YES	5.57	52.13	YES
NL	2.30	2.30	NO	3.92	21.68	YES	1.54	17.98	NO
NO	21.99	20.12	YES	3.99	22.14	YES	2.00	22.73	YES
NZ	79.23	57.31	YES	17.23	69.41	YES	8.56	73.60	YES
PT	83.70	59.59	YES	14.48	61.81	YES	8.35	68.77	YES
SE	65.72	49.96	YES	12.44	55.58	YES	5.90	54.32	YES
US	9.49	9.15	YES	5.49	29.11	YES	3.79	38.84	YES

F-stat and TR^2 statistics have been estimated in EViews 8.0

K corresponds to lag length of the model, and tests are done at 5% significance level.

ARCH effects have been detected in most series residuals, except for inflation series of Canada, Germany and Ireland. ARCH LM test is not a powerful test so despite the ARCH test result we still going to fit the parametric volatility part to all the series. For the robustness checks of volatility rolling standard deviation will be used, where parametric model efficiency will be in doubt.

A second parametric measure will be derived for the robustness checks – GARCH (1,1) model. For this measures ARFIMA (0,d,0) specification will be used, where d parameter values can be found in Table 5-4. Lagrange Multiplier tests for the ARCH effects have been run for the data. Results are reported in Table 5-7.

Table 5-7 ARCH LM test results for ARFIMA (0,d,0) specification

	K=1			K=6			K=12		
	F stat	TR^2	Presence of ARCH effects	F stat	TR^2	Presence of ARCH effects	F stat	TR^2	Presence of ARCH effects
AT	84.28	59.88	YES	24.43	85.79	YES	12.56	87.58	YES
AU	79.71	57.57	YES	15.57	64.93	YES	7.79	65.76	YES
BE	41.06	34.41	YES	9.24	44.49	YES	5.68	52.86	YES
CA	1.35	1.35	NO	0.55	3.35	NO	0.33	4.12	NO
CH	35.46	29.95	YES	11.52	51.16	YES	4.01	39.89	YES
DE	4.08	3.97	YES	0.78	4.82	NO	0.79	9.98	NO
DK	21.19	19.13	YES	6.64	33.48	YES	3.90	38.89	YES
ES	15.61	14.63	YES	8.01	39.77	YES	3.97	40.33	YES
FI	38.07	32.30	YES	10.96	50.64	YES	6.06	55.42	YES
FR	14.01	13.22	YES	7.52	37.80	YES	4.38	43.56	YES
GB	9.42	9.08	YES	5.55	29.37	YES	2.94	31.63	YES
IE	0.80	0.81	NO	0.28	1.78	NO	0.64	8.21	NO
IT	4.20	4.16	YES	2.50	14.42	YES	3.53	36.75	YES
JP	20.32	18.63	YES	6.78	34.72	YES	4.52	44.64	YES
NL	0.49	0.50	NO	4.54	24.69	YES	1.43	16.79	NO
NO	21.26	19.41	YES	3.68	20.50	YES	1.77	20.38	NO
NZ	14.06	13.31	YES	7.18	36.73	YES	3.54	37.07	YES
PT	92.47	63.87	YES	18.92	73.67	YES	10.32	78.37	YES
SE	64.53	49.27	YES	12.21	54.81	YES	5.77	53.47	YES
US	15.23	14.30	YES	6.82	34.93	YES	4.73	46.19	YES

F-stat and TR^2 statistics have been estimated in EViews 8.0

K corresponds to lag length of the model, and tests are done at 5% significance level.

ARCH effects have been detected for all countries data series at all lag length or at some lag length except for Canada and Ireland. As before due to low power of the ARCH LM test, GARCH (1,1) model based on ARFIMA(0,d,0) specification will be derived for all countries' series.

5.1.4 Volatility measures descriptive statistics.

Estimated volatility measures have been averaged from monthly to yearly frequency. Descriptive statistics describing final estimated volatility models of inflation series are present below in Table 5-8, additionally graphs of inflation volatility measures by country have been plotted in Appendix A4.

By observing the graphs in Appendix A4 it becomes obvious that rolling standard deviation produces volatility measures with the smallest range (scaling of the graphs is evident of this). It can be supported with comparative data description from Table 3-1 where rolling standard deviation measure has smallest mean, range and standard deviation values. Even though GARCH based measures have smallest minimal values, they have largest maximum values. Both GARCH based measures have similar mean and minimal values. However, GARCH based measure with moving average part has highest range of the series together with the largest maximum value. Thus, it has largest standard deviation value meaning it is the most volatile.

Within the countries picture might look a bit different. For most of the countries GARCH based volatilities have higher values range and standard deviation. For Germany, Spain and the United States volatility measure based on rolling standard deviation measure has wider range and, thus, higher standard deviation value. Overall, peak values are usually larger with GARCH based measures for all countries excluding the countries listed above (Germany, Spain and the United States). For all countries except Austria, Australia, Finland, France, Italy and Norway, GARCH based volatility with moving average part yields higher peak values, range and consequently, higher standard deviation.

Table 5-8 Descriptive statistics and normality tests of yearly volatility measures of inflation series

	Number of observations	Mean	Median	Maximum	Minimum	St.Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
Austria (AT)										
ARFIMA(0,d,0) - MA4	50	0.45	0.27	2.56	0.03	0.54	1.95	7.27	69.59	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.99	0.36	9.03	0.01	1.77	3.05	12.75	275.65	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.85	0.33	7.94	0.01	1.56	3.21	13.71	324.85	0.00
Australia (AU)										
ARFIMA(0,d,0) - MA4	50	0.68	0.53	2.52	0.20	0.45	1.92	7.50	72.86	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.97	0.66	5.90	0.32	0.95	3.25	15.77	427.41	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.94	0.66	5.31	0.32	0.88	3.03	13.83	321.06	0.00
Belgium (BE)										

	Number of observations	Mean	Median	Maximum	Minimum	St.Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
ARFIMA(0,d,0) - MA4	50	0.20	0.19	0.66	0.02	0.15	0.81	3.19	5.48	0.06
ARFIMA (0,d,0) - GARCH (1,1)	50	0.14	0.09	0.85	0.02	0.15	3.00	13.93	323.99	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.15	0.08	1.13	0.03	0.19	3.09	14.59	359.22	0.00
Canada (CA)										
ARFIMA(0,d,0) - MA4	50	0.50	0.48	1.63	0.12	0.25	2.24	10.03	144.80	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.49	0.37	3.18	0.19	0.44	4.91	30.39	1763.64	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.49	0.37	3.26	0.19	0.45	4.92	30.44	1770.22	0.00
Switzerland (CH)										
ARFIMA(0,d,0) - MA4	50	0.24	0.20	1.14	0.04	0.18	2.89	14.22	10.80	0.49
ARFIMA (0,d,0) - GARCH (1,1)	50	0.15	0.09	0.94	0.04	0.17	2.87	11.66	6.93	0.34
ARFIMA (0,d,1) - GARCH (1,1)	50	0.15	0.08	1.28	0.04	0.21	4.03	20.17	6.75	0.01
Germany (DE)										
ARFIMA(0,d,0) - MA4	19	0.25	0.23	0.60	0.08	0.14	1.02	3.46	3.45	0.18
ARFIMA (0,d,0) - GARCH (1,1)	19	0.10	0.10	0.18	0.05	0.04	0.89	3.09	2.54	0.28
ARFIMA (0,d,1) - GARCH (1,1)	19	0.09	0.09	0.13	0.08	0.01	1.75	5.77	15.77	0.00
Denmark (DK)										
ARFIMA(0,d,0) - MA4	44	0.47	0.29	1.60	0.03	0.43	0.92	2.59	6.54	0.04
ARFIMA (0,d,0) - GARCH (1,1)	44	0.78	0.38	3.87	0.04	0.85	1.53	5.32	26.93	0.00
ARFIMA (0,d,1) - GARCH (1,1)	44	1.02	0.30	6.94	0.04	1.46	1.98	7.34	63.40	0.00
Spain (ES)										
ARFIMA(0,d,0) - MA4	50	0.32	0.25	1.04	0.05	0.23	1.10	3.57	10.84	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.29	0.18	1.01	0.10	0.22	1.61	4.79	28.36	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.29	0.18	0.94	0.11	0.21	1.53	4.28	22.94	0.00
Finland (FI)										
ARFIMA(0,d,0) - MA4	50	0.83	0.56	3.08	0.17	0.67	1.56	5.05	29.00	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	1.66	0.89	10.23	0.34	2.07	2.69	10.15	166.85	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	1.58	0.96	8.77	0.27	1.91	2.59	9.51	144.28	0.00
France (FR)										
ARFIMA(0,d,0) - MA4	50	0.34	0.28	1.25	0.07	0.27	1.30	4.66	19.84	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.48	0.16	1.83	0.01	0.63	1.14	2.65	11.15	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.47	0.16	1.80	0.01	0.61	1.15	2.67	11.24	0.00
Great Britain (GB)										
ARFIMA(0,d,0) - MA4	50	0.71	0.63	2.20	0.24	0.40	2.18	8.31	98.43	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	1.02	0.61	4.84	0.36	0.95	2.28	8.04	96.23	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	1.02	0.57	5.34	0.31	1.03	2.39	8.79	117.66	0.00
Ireland (IE)										
MA4	23	0.93	0.80	2.48	0.20	0.62	0.89	3.15	3.07	0.22
GARCH (1,1)	23	1.47	1.36	3.03	0.44	0.72	0.52	2.16	1.72	0.42

	Number of observations	Mean	Median	Maximum	Minimum	St.Deviation	Skewness	Kurtosis	Jarque –Bera statistic	Jarque-Bera p-value
ARFIMA (0,d,1) - GARCH (1,1)	20	1.52	1.22	3.17	0.40	0.91	0.44	1.73	1.97	0.37
Italy (IT)										
ARFIMA(0,d,0) - MA4	50	0.71	0.55	2.55	0.17	0.54	1.58	5.21	31.03	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	1.35	0.70	8.51	0.22	1.60	2.42	9.72	143.05	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	1.28	0.59	8.28	0.22	1.58	2.45	9.65	142.27	0.00
Japan (JP)										
ARFIMA(0,d,0) - MA4	50	0.51	0.38	1.90	0.06	0.36	1.85	6.59	55.38	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.57	0.27	3.06	0.11	0.70	2.35	7.88	95.46	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.56	0.27	4.08	0.12	0.76	2.97	12.30	254.01	0.00
Netherlands (NL)										
ARFIMA(0,d,0) - MA4	50	0.58	0.52	1.80	0.13	0.31	1.37	5.97	33.95	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.67	0.42	4.63	0.22	0.80	3.46	15.55	427.76	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.64	0.40	5.13	0.21	0.84	3.96	19.53	699.89	0.00
Norway (NO)										
ARFIMA(0,d,0) - MA4	50	1.20	1.26	4.19	0.05	0.86	0.77	4.22	8.08	0.02
ARFIMA (0,d,0) - GARCH (1,1)	50	3.98	3.48	22.77	0.08	3.82	2.53	12.97	260.45	0.00
ARMA (0,1) - GARCH (1,1)	53	4.15	3.73	21.21	0.02	3.85	1.72	8.33	88.83	0.00
New Zealand (NZ)										
MA4	53	2.18	1.03	14.69	0.27	2.83	2.79	11.17	216.06	0.00
GARCH (1,1)	53	20.72	3.31	260.36	0.48	43.84	3.84	19.48	730.13	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	20.39	2.35	262.88	0.43	45.13	3.76	18.79	637.07	0.00
Portugal (PT)										
ARFIMA(0,d,0) - MA4	50	0.39	0.34	1.05	0.04	0.26	0.71	2.80	4.30	0.12
ARFIMA (0,d,0) - GARCH (1,1)	50	0.47	0.34	1.72	0.20	0.32	2.34	8.86	117.26	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.50	0.30	2.51	0.14	0.49	2.38	9.02	122.79	0.00
Sweden (SE)										
ARFIMA(0,d,0) - MA4	50	0.28	0.23	1.05	0.01	0.24	1.10	4.09	12.49	0.00
ARFIMA (0,d,0) - GARCH (1,1)	50	0.30	0.16	1.35	0.05	0.31	1.77	5.53	39.52	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.31	0.14	2.08	0.05	0.39	2.73	11.50	212.90	0.00
United States (US)										
ARFIMA(0,d,0) - MA4	50	0.18	0.16	0.44	0.04	0.10	0.88	3.28	6.65	0.04
ARFIMA (0,d,0) - GARCH (1,1)	50	0.08	0.06	0.29	0.02	0.06	1.48	4.91	25.84	0.00
ARFIMA (0,d,1) - GARCH (1,1)	50	0.08	0.06	0.26	0.02	0.06	1.31	4.18	17.22	0.00

Please note volatility measures and all relevant analysis are estimated using EViews 8.0.

5.2 Inflation Volatility effect on labour market performance.

The effect of inflation volatility on labour market performance has been estimated using a wide range of panel data models. Similarly to the last chapter, the choice of optimal estimation technique has been done with the assistance of the diagnostic testing of the models. In contrast to the previous chapter, panel time series aspect of the macroeconomic model could not have been exploited here, as inflation volatility series are fractionally integrated. This violates the cointegrating relationship assumptions and undermines the use of error correction model and Granger causality. Instead Corrected Least Square Dummy models have been used instead, as proposed by Bruno (2005).

General expectation is that inflation volatility will have adverse effect on labour market performance. There is no previous theoretical literature binding the two variables in one context, however, our hypothesis is based on previous empirical research. Feldmann (2012), based on 20 industrial countries, has found an adverse effect of inflation volatility on the unemployment rate.

5. 2.1 Baseline model derivations: inflation volatility effect on unemployment.

The choice of unemployment rate from Annual Labour Force Statistics (ALFS) for the baseline model is not random. It provides the longest time coverage of the series. The same principle has been applied for the choice of optimal explanatory variables model among its alternatives in construction of the baseline model. Baseline model for the analysis is:

$$Urt = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it},$$

where *Urt* is Unemployment Rate from ALFS , X_{it} is a vector of explanatory variables, α_i is country fixed effects, d_t is yearly time dummies and u_{it} is an idiosyncratic error term. Vector of explanatory variables includes variables measuring inflation volatility, tax wedge, output gap, employment protection legislation, product market regulation, average benefit replacement rate and union density.

The Wooldridge (2002) test has been run to test the null hypothesis of no serial correlation. Alternative of first-order serial correlation in the error terms is not rejected due to the large F-test statistic value of 116.169 (corresponding p value of 0.000). For further diagnostic checks three models have been derived to assist with the tests – pooled OLS (country clustered), RE and FE. The results are presented in Table 5-9. Use of time effects has been confirmed for all models by the relevant F-tests. Overall, all models suggest that inflation volatility has an insignificant effect on unemployment rate. The validity of the results has to be examined. Pooled OLS provides comparatively large values of variables' coefficients, R^2 and standard errors. It might be a consequence of autocorrelation in residuals as indicated by Wooldridge (2002) test. Breusch-Pagan Lagrange Multiplier test is evident of distinctive country effects implying pooled OLS is a poor derivation method. Left with two alternatives of random and fixed effects panel estimation techniques, Hausman test is used to make the choice for modelling. So far the choice has been made in favour of Fixed Effects model, as its estimator is consistent. Next question lays in the power of models assumption. Homoscedasticity in fixed effects model is checked by the means of the Modified Wald test for groupwise heteroskedasticity. Results are indicative of presence of heteroskedasticity. Violation of models fundamental assumptions leads to misleading results.

Table 5-9 Determinants of unemployment for OECD countries (1985-2011) including inflation volatility measures

	Pooled OLS (clustered by country)	Fixed effects	Random effects	Fixed Effects model with SE robust to serial correlation and heteroskedasticity	Random effects model with SE robust to serial correlation and heteroskedasticity
Output Gap	-0.503***	-0.541***	-0.552***	-0.541***	-0.552***
Tax Wedge	0.158**	0.125***	0.118***	0.125***	0.118***
Inflation volatility (pv1)	0.836	0.196	0.207	0.196	0.207
Product Market Regulation	2.513*	0.957***	0.989***	0.957	0.989
Employment Protection Legislation	-0.640*	0.758	0.228	0.758	0.228
Average Benefit Replacement Rate	0.009	0.091***	0.074***	0.091***	0.074***
Union Density	-0.049	-0.017	-0.038*	-0.016	-0.038
Time Effects	YES	YES	YES	YES	YES
Standard Error of Inflation Volatility	1.067	0.226	0.225	0.296	0.311
R^2 within		0.593	0.591	0.593	0.591
R^2 between		0.057	0.095	0.057	0.095
R^2 overall	0.365	0.179	0.252	0.179	0.252
Time Effects F-test	7.87 (0.000)	2.09 (0.002)	53.63 (0.001)	14.75 (0.000)	185.02 (0.000)
Wooldridge test (2005)	116.169 (0.0000)				
Mod. Wald Test for Heteroskedasticity		923.62 (0.000)			

Hausman test[1]		19.52 (0.034)	19.52 (0.034)	10.807 (0.1473)	10.807 (0.1473)
Breusch-Pagan LM Test	3195.63 (0.000)		3195.63 (0.000)		
Pesaran (2004) cross-sectional dependence test				4.240 (0.000)	4.240 (0.000)
Average absolute value of the off-diagonal elements				0.332	0.332
Friedman cross-sectional dependence test				57.181 (0.000)	57.181 (0.000)
Free's cross-sectional dependence test				4.052	4.052
Average Number of Years[2]	24.6	24.6	24.6	24.6	24.6
Number of Countries	20	20	20	20	20
Number of Observations	492	492	492	492	492

Baseline specification: $\mathrm{Urt} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$
[1] Hausman test results reported are based on regressions without time effects.
[2] Average number of years is used as panel is unbalanced
* Result is significant at 10% significance level
** Result is significant at 5% significance level
*** Result is significant at 1% significance level

Presence of serial correlation and heteroskedasticity in the error term might be liable not only for adverse results, but may bias Hausman test statistics as well. In search of the answers, fixed and random effects models corrected for the presence of autocorrelation and heteroskedasticity have been estimated. As can be seen from the results in Table 5-9, even though introduction of robust standard errors has decreased standard errors, it has still left inflation volatility effect on unemployment insignificant. Does variation in standard errors have enough power to alteration of Hausman test results? Following Schaffer and Stillman (2010), it was decided to use "xtoverid" command in STATA for the heteroskedasticity and autocorrelation robust Hausman test.

Table 5-10 Determinants of unemployment for OECD countries (1985-2011): comparison of inflation volatility indicators

	Pooled OLS with Driscoll-Kraay SE	Fixed Effects with Driscoll and Kraay SE	Fixed effects with Driscoll-Kraay SE where inflation volatility is measured as pv1	Fixed effects with Driscoll-Kraay SE where inflation volatility is measured as pv2	Fixed effects with Driscoll-Kraay SE where inflation volatility is measured as pv3
Output Gap	-0.490***	-0.530***	-0.540***	-0.539***	-0.539***
Tax Wedge	0.162***	0.128***	0.121***	0.120***	0.120***
Inflation volatility	0.634**	0.022	0.242	0.027	0.023
Product Market Regulation	0.770***	0.365	0.418*	0.435*	0.429*
Employment Protection Legislation	-0.436***	0.575	0.625	0.668	0.671
Average Benefit Replacement Rate	0.013	0.095***	0.091***	0.092***	0.092***
Union Density	-0.053***	-0.019	-0.036	-0.0039	-0.038

Time Effects			YES	YES	YES
Time dummies[1]	YES	YES			
Standard Error of Inflation Volatility	0.273	0.206	0.239	0.055	0.055
Wooldridge(2002) Adapted Hausman test[2]	1.54 (0.2130)	1.54 (0.2130)			
Hoechle(2007) Adapted Hausman test[2]	2.90 (0.0304)	2.90 (0.0304)			
R^2 within		0.547	0.588	0.567	0.587
R^2 between					
R^2 overall	0.325				
Average Number of Years[2]	24.6	24.6	24.6	24.6	24.6
Number of Countries	20	20	20	20	20
Number of Observations	492	492	492	492	492

Pooled OLS and Fixed Effects models with Driscoll-Kraay Standard Errors, where unemployment rate is provided by the indicator from Annual Labour Force Statistics.
[1] Time dummies included are for years 1991, 2002 and 2008
[2]Hausman test results reported are based on regressions without time effects.
[3] Average number of years is used as panel is unbalanced
* Result is significant at 10% significance level
** Result is significant at 5% significance level
*** Result is significant at 1% significance level

Test of over-identifying restrictions produces a Sargan test value of 10.807. Corresponding p-value is indicative of RE model being the most suitable one for the further analysis of the model. This result has been supported by Hoechle (2007) adapted Wooldridge (2002) test.

Diagnostic checks for cross-sectional dependence have been run. Free's, Friedman's and Pesaran tests indicate its presence. Driscoll-Kraay standard errors are to be used to avoid bias of autocorrelation, heteroskedasticity and cross-sectional dependence. Alteration to the Hausman test should be done as well as to chose among pooled OLS or fixed effects. Adapted Wooldridge (2002) test offers us a chance to do robust Hausman test when residuals are independently and identically distributed. This test prefers pooled OLS method to fixed effects modelling. However, results should be interpreted with care, as test results are sensitive to degree of cross-sectional dependence. Hoechle (2007) proposes alternative test that uses Driscoll-Kraay standard errors. This test is robust to spatial and cross-sectional dependence. Results of the test suggest superiority of the fixed effects model over pooled OLS. Consideration of both tests provides mixed result, however Hoechle (2007) test is stricter than its analogues when errors are not independently and identically distributed. So fixed effects model has been chosen as the technical framework for the case where Driscoll-Kraay errors are used.

Results of Fixed Effects model with Driscoll-Kraay standard errors indicate that inflation volatility and unemployment are positively correlated. However, this relationship is not significant. This result holds even if alternative GARCH model based volatility measures are being used. Is there enough evidence gathered to formally state that inflation volatility has no significant impact on unemployment rate? No. As we have to check the consistency of the result under dynamic panel model and in the presence of causality concerns.

One of the ways to solve for unobserved endogeneity is to use dynamic model. In previous chapter to address same issues panel time series methods have been used (e.g. Pesaran (2006) Common Correlated Effects Mean Estimator). The use of these methods is unattainable here, because inflation volatility is a fractionally integrated variable. It violates one of the fundamental assumptions for the model for all variables to be integrated of order one.

Static and dynamic models produce distinctive results for the analysis of inflation volatility on unemployment rate. So far it has been shown that first difference inflation volatility has significant effect on unemployment rate. Dynamic models tend to describe model behaviour from the short run perspective rather than long-run. So do our results suggest that inflation volatility effects unemployment only in the short-run? Or fixed effects model results are biased due to unobserved heterogeneity in the model?

The way to solve this dilemma has been described by Bruno (2005), where least square dummy variable approach is used with variance corrected by approximations derived from Arellano-Bond estimator. The choice of Arellano-Bond estimator among alternatives (Blundell-Bond (1998) or Anderson-Hsiao (1982)) is guided by a better fit for models as has been shown by Sargan and autocorrelation tests. Inclusion of lagged unemployment rate variable still removes all the relevant endogeneity bias associated with wages sluggishness. Advantage of the technique is that it is a fixed effects model at the heart of it. Thus it avoids major critique of Arellano-Bond modelling of "too many instruments" (Roodman (2009)). Another issue of no smaller importance is that this model is generally a good fit for both micro and macroeconomic panels (Bruno 2005).

Fixed effects model with bias corrected (order of $\frac{1}{NT^2}$) bootstrapped standard errors (1000 iterations) has been estimated for all volatility measures. Results (Table 5-11) in magnitude are similar to GMM estimators, but corrected fixed effects models suggest weaker significance of the effect with only one volatility measure being significant among three. How does this result compare with previous research? Feldmann (2012) results suggest that inflation volatility has increasing effect on unemployment. In the article, unemployment rate has been approximated by Harmonised unemployment rate variable. For more efficient comparison as to minimise the possible differences between the models, ALFS derived unemployment rate has been substituted by Harmonised unemployment rate and results being reported in Table 5-11a.

Table 5-11 Determinants of unemployment for OECD countries (1985-2011): dynamic model

	Least Square Dummy Variable Corrected Estimator with bootstrapped SE[2] with correction of up to an order of $\frac{1}{NT^2}$ (Bruno2005)		
	Baseline specification	Baseline specification where volatility is measured as pv2	Baseline specification where volatility is measured as pv3
Lagged unemployment rate	0.806***	0.808***	0.806***
Output Gap	-0.257***	-0.250***	-0.256***
Tax Wedge	-0.043***	-0.049***	-0.043***
Inflation volatility	0.152	0.060*	0.044
Average Benefit Replacement Rate	0.011	0.014	0.014
Employment Protection Legislation	-0.055	-0.055	-0.022
Product Market Regulation	0.120	0.136*	0.117
Union Density	-0.015	-0.018	-0.016
Standard Error of Inflation Volatility	0.112	0.036	0.036
Average Number of Years[1]	23.6	23.45	23.6
Number of Countries	20	20	20
Number of Observations	472	469	472

[1] "Average number of years" is reported, as panel is unbalanced
[2] For SE bootstrap the step is 1000
* Result is significant at 10% significance level
** Result is significant at 5% significance level
*** Result is significant at 1% significance level

Once alternative measure of unemployment rate has been used, general significance of the inflation volatility has gained more power. Directionally, results are in line with previous studies. However, the use of different volatility measures makes it harder to compare the magnitude of the effects. Feldmann (2012) approximates volatility by using two rolling standard deviation measures – long-run (with lag length from 6 to 10) and short-run (lag length from 1 to 5). Whereas in this study one general rolling standard deviation measure has been used that combines short–run and long-run aspects in it with lag length of 12. Crude approximation for the combined effect of inflation volatility on unemployment can be achieved by coefficients summation. This will amount to 0.26, whereas in our study rolling standard deviation volatility measure has yielded coefficient of 0.205. The coefficients difference is small taking into account different lag structure, nature of approximation for LSDVC model, as well as the fact that current study measure is taking stationarity of the series into account. Moving on to GARCH based measures. It is hard to compare them to standard deviation based measures, due to different nature of estimation. Lack of studies on the direct link between inflation volatility based on GARCH measures contributes to novelty aspect of the research, however disability to compare research results to previous studies limits our estimates discussion.

Table 5 -11a Alternative inflation volatility measures effect on harmonised unemployment rate for OECD countries

	Baseline specification	Baseline specification where volatility is measured as pv2	Baseline specification where volatility is measured as pv3
Unemployment Rate Indicator	Harmonised Unemployment Rate		
Lagged unemployment rate	0.772***	0.774***	0.773***
Output Gap	-0.263***	-0.256***	-0.263***
Tax Wedge	-0.463***	-0.052***	-0.047***
Inflation volatility	0.205*	0.071**	0.057
Average Benefit Replacement Rate	0.013*	0.017*	0.017*
Employment Protection Legislation	0.078	0.085	0.113
Product Market Regulation	0.055	0.071	0.048
Union Density	-0.003	-0.006	-0.004
Standard Error of Inflation Volatility	0.110	0.033	0.036
Average Number of Years[1]	22.4	22.2	22.4
Number of Countries	20	20	20
Number of Observations	425	422	425

[1] "Average number of years" is reported, as panel is unbalanced
[2] For SE bootstrap the step is 1000
* Result is significant at 10% significance level, ** Result is significant at 5% significance level
*** Result is significant at 1% significance level

Previously time effects have been included into all of the regression analyses here. Nevertheless, please note that time effects (dummy variables for every year less one) have not been included into Arellano-Bond and LSDVC models. This is due to software limited options for the modelling that restricts use of factor variables and time-series operators. However, panel of twenty countries in the research includes EU15 countries. Such an event as Euro introduction should have not passed unnoticed for economies and labour market performance of the countries involved. Directly it affects only some countries from the sample, but the proportion of those countries to the whole sample is large. So it has been decided to see if the results are still robust, if this event is taken into account. Dummy variable for the year 2002 has been generated and regressions have been re-run inclusive of this variable.

In Table 5-12, results have been reported only for the inflation volatility coefficients and corresponding p-values. Browsing through the previous and current results, it should be concluded that controlling for euro currency introduction has not changed our results significantly.

Table 5-12 Determinants of unemployment for OECD countries (1985-2011): inclusion of time dummy for introduction of common currency (EURO)

	COEFFICIENT OF PV3 VARIBALE (CORRESPONDING P-VALUE)	COEFFICIENT OF PV2 VARIBALE (CORRESPONDING P-VALUE)	COEFFICIENT OF PV3 VARIBALE (CORRESPONDING P-VALUE)
	Unemployment Rate (ALFS)		
LSDVC – Bruno (2005)[1]	0.146 (0.195)	0.059 (0.100)	0.043 (0.231)
	Harmonised Unemployment Rate		
LSDVC – Bruno (2005)[1]	0.199 (0.071)	0.070 (0.031)	0.056 (0.122)

[1]In LSDVC model for SE bootstrap number of iterations is 1000

A country effect is another important feature that has to be addressed to establish robustness of the results to country composition of the panel data. Regressions have been re-run with the rolling exclusion of one individual country data one by one from the sample. Analysis has been done using Arellano-Bond (1991) heteroskedasticity robust standard errors and corrected Least Squares Dummy variables distinctively for all three measures of inflation volatility. Arellano-Bond tests together with Sargan tests approve the choice of modelling the unemployment rate. In the case of harmonised unemployment rate they are weaker. So to check validity of the model tests have been run on heteroskedasticity robust model and second order autocorrelation has been detected. Results are presented in Table 5-13.

Table 5-13 Determinants of unemployment for OECD countries (1985-2011): country effects

	Least Squares Dummy Variables – Bruno (2005)		
	COEFFICIENT OF PV1 VARIBALE (CORRESPONDING P- VALUE)	COEFFICIENT OF PV2 VARIBALE (CORRESPONDING P- VALUE)	COEFFICIENT OF PV3 VARIBALE (CORRESPONDING P- VALUE)
	Harmonised Unemployment Indicator from Eurostat		
Australia[2]	0.136* (0.093)	0.045* (0.097)	0.029 (0.249)
Austria	0.157* (0.057)	0.048* (0.080)	0.033 (0.212)
Belgium	0.158* (0.062)	0.053* (0.076)	0.036 (0.183)
Canada	0.144* (0.092)	0.047* (0.084)	0.031 (0.220)
Denmark	0.117 (0.123)	0.051* (0.069)	0.037 (0.102)
Finland	0.187** (0.032)	0.054* (0.090)	0.040 (0.166)
France	0.156* (0.064)	0.056* (0.056)	0.038 (0.158)
Germany	0.166* (0.096)	0.047* (0.089)	0.030 (0.239)
Ireland	0.145 (0.114)	0.036 (0.147)	0.028 (0.290)
Italy	0.179** (0.026)	0.047* (0.082)	0.037 (0.158)
Japan	0.138* (0.091)	0.047* (0.093)	0.029 (0.272)
Netherlands	0.173** (0.036)	0.069** (0.040)	0.051* (0.077)
New Zealand	0.136 (0.110)	0.041* (0.097)	0.026 (0.268)
Norway	0.193* (0.063)	0.111** (0.016)	0.104 (0.137)
Portugal	0.133* (0.089)	0.041 (0.176)	0.022 (0.366)
Spain	0.109* (0.097)	0.037* (0.083)	0.022 (0.270)
Sweden	0.153* (0.086)	0.051* (0.099)	0.034 (0.234)
Switzerland	0.157* (0.058)	0.050* (0.082)	0.035 (0.203)
United Kingdom	0.168** (0.049)	0.060** (0.046)	0.043 (0.133)
United States	0.150* (0.066)	0.049* (0.090)	0.034 (0.219)

[1]In LSDVC model for SE bootstrap number of iterations is 100
2In this example countries indicated are the ones excluded from the sample
* Result is significant at 10% significance level
** Result is significant at 5% significance level
*** Result is significant at 1% significance level

Results are relatively robust to country composition of the data. GARCH based measure of volatility (pv2) has positive impact on unemployment rate despite the country composition. This statement is always significant at least at 10% significance level. Conclusions are less powerful for harmonised unemployment rate case, where significance of the outcome reduces to 0.147 and 0.176 respectively once Ireland or Portugal countries are out of the sample. This is logical as effect of volatility on labour market depends on individual countries' economies. Some countries are better equipped with government and labour market polices and can deflect negative follow-ups of uncertainty better. Some countries' economies are more fragile and bear the burden of volatilities to the full extent. Portugal and Ireland look as relatively weaker economies on the overall picture of today's EU15. So it is expected that they will have higher costs to volatilities. So what model provides more reliable results? ALFS unemployment rate results are more reliable as the econometric model to estimate them is a good fit and it has the highest number of observations. Harmonised unemployment based conclusions are sensitive to what volatility measure is being used. Looking at alternative volatility measures such as standard deviation based – PV1, Portugal looses its less "equipped for volatility" status, but Ireland retains it.

Similar to this study's previous findings, third volatility measure is the least significant among all regressions, the lesser insignificant is rolling standard deviation variable. The most significant variable is GARCH based measure of (0,d,0)-GARCH (1,1). Second measure of volatility (pv2) looks the most appealing as it captures significant effect of inflation volatility on labour market performance more often that the other measures. So it has been decided to alter baseline specification to make it inclusive of (0,d,0)-GARCH measure as it is a better performer.

5.2.2 Inflation volatility effect on Labour Market Performance: other indicators.

Volatility effect on unemployment rate has been established, but what about other labour market performance indicators? Baseline specification has been assumed for the purpose of answering this question and Arellano-Bond Corrected Least Square Dummy Variable estimator has been used. Results are present in Table 5-14.

As expected, volatility has a dampening effect on employment rate and this is a significant result at 10% significance level. However, in magnitude the result is not symmetrical to the unemployment rate. Inflation volatility increases unemployment rate by a greater value (0.011) in proportion to its depressing effect on employment rate. It is not a surprise as inflation volatility hampers labour market participation. For example, a one percent increase in volatility decreases labour market activity rates by 0.038 percentage points. This inhibiting effect of volatility on labour market indicators has been translated to other performance variables. The number of discouraged workers and the duration of unemployment of those unemployed for less than 6 months increases together with volatility. However, this result for the later two variables looses its significance even at 10% level.

From the first looks at the data analysis results volatility disturbs structural rate of unemployment (measured by NAIRU). However this result legitimacy is questionable as validity of Arellano-Bond (1991) estimator is questionable, so as the LSDV model that has been corrected by Arellano-Bond Standard errors.

Table 5-14 Determinants of labour market performance for OECD countries (1985-2011): dynamic model

	Employment rate	Activity rate	Non-accelerating rate of unemployment	Discouraged Workers	Duration of unemployment less than 6 months
Lagged dependent variable	0.824***	0.973***	0.976***	-0.163**	0.841***
Output Gap	0.224***	0.096***	-0.045***	-0.101***	0.908***
Tax Wedge	0.008	0.001	-0.027***	0.003	0.072
Inflation volatility	-0.049*	-0.038**	0.019*	0.005	0.008
Average Benefit Replacement Rate	0.004	0.007	-0.002	0.007	0.034
Employment Protection Legislation	0.636	-0.235	-0.041	1.791***	-0.081
Product Market Regulation	0.704***	0.306***	0.116***	0.030	-0.245
Union Density	-0.072***	-0.0217**	-0.042	0.058**	-0.054
Standard Error of Inflation Volatility	0.029	0.020	0.012	0.036	0.171
Sargan Test	270.58 (1.000)	145.57 (1.000)	2637.41 (0.000)	173.41 (1.000)	510.24 (1.000)
Arellano-Bond test for first order autocorrelation	-3.62 (0.000)	-5.35 (0.000)	0.85 (0.398)	-11.8 (0.000)	-7.71 (0.000)
Arellano-Bond test for second order autocorrelation	-0.65 (0.513)	-0.87 (0.385)	0.86 (0.392)	8.30 (0.000)	-0.99 (0.320)
Arellano-Bond test for first order autocorrelation in heteroskedasticity robust model	-2.57 (0.01)	-2.877 (0.004)	0.304 (0.761)	-1.237 (0.216)	-3.51 (0.000)
Arellano-Bond test for second order autocorrelation in heteroskedasticity	-0.648 (0.517)	-1.00 (0.317)	0.763 (0.446)	1.242 (0.214)	-0.954 (0.340)
Time dummies	YES	YES	YES	YES	YES
Number of Countries	20	20	20	14	20
Number of Observations	241	241	469	160	448

[1]In LSDVC model for SE bootstrap number of iterations is 100
* Result is significant at 10% significance level
** Result is significant at 5% significance level
*** Result is significant at 1% significance level

5.2.3 Conclusion

Regressions based on pooled, random or fixed effects with or without corrections of heteroskedasticity, spatial and temporal dependence, have not been evident of any significant relationship between inflation volatility and unemployment. However, in dynamic modelling using least square dummies with variance corrected by Arellano-Bond estimator (1991), inflation volatility coefficients gain significant power.

In baseline specification using different volatility measures and LSDVC method results in findings of significant positive relationship between inflation volatility and unemployment rate (ALFS definition). But this is true only in the case of GARCH based volatility measure without the moving average part. However, once harmonised unemployment rate is used in the baseline regression instead of ALFS one, then additionally rolling standard deviation based measure coefficient gains significance.

When looking at the other components of labour market, according to baseline specification, where volatility measure is based on rolling standard deviation, inflation volatility is negatively associated with employment and activity rates. It is also positively correlated with structural unemployment rates.

It should be noted that inter variable relationships described here should not be viewed as causal impacts because of methodology limitations, but should be viewed more as correlations.

Chapter 6. Interest rate volatility effect on labour market performance.

6.1 Volatility measures.

Volatility of interest rate series is to be described by a variety of non-parametric and parametric models. In particular, the computation of rolling standard deviation and GARCH based measures is the focus of this section. Distinctive property of interest series is its asymmetrical reaction to economic booms, shocks and crises. This is explained by Central Bank intervention into interest rate formation ruled by desire to track inflation and money flows (e.g. Fed, Bank of England and ECB holding interest rates at low of 0.5%). How to model volatility of asymmetric response models? Based on previous research and software availability, choice will be made among GARCH, GJR-GARCH (Glosten et.al. (1993)), QGARCH (Sentana(1995)), and PARCH (Engle and Bollerslev (1986)). These models have been used before in previous analysis of interest rate volatility (e.g. Bali (2007)).

In order to capture volatility, it has been decided to use money market rate, rather than alternatives, because it is a more sensitive measure. Money market rate (MMR) series that are used for the purpose have been obtained on monthly basis, but have already been averaged to annual frequency. Using monthly data gives an advantage of a large number of observations to start with and smaller observations loss due to iterative techniques used. Disadvantage of the high frequency data is seasonality, so we have constructed seasonality tests by using monthly dummies. Results suggest no seasonal adjustment is required.

6.1.1. Unit root tests

Stationarity of the series needs to be established before any model fittings are performed. We will start with classical Augmented Dickey Fuller (ADF) Test where optimal lag length has been chosen by the Schwarz Information Criteria. Regression equation has exogenous structure – constant added. Trend has not been added as series do not look like trended and to avoid over specification of the model that decreases power of the test. Results of the Unit Root Tests are reported in Table 6-1.

Table 6-1 Unit root tests for interest rate series

Country Name	significance level, %	ADF		Phillips -Perron		KPSS		Conclusion	Country Code
		t-statistic	no.of unit roots	t-statistic	no.of unit	test statistic	no. of unit		

					roots		roots		
Austria	1%, 5% , 10%	-2.440248	1	-1.743356	1	1.408951	1	1	AT
Australia	1%, 5% , 10%	-1.832894	1	-1.921123	1	0.948601	1	1	AU
Belgium	1%	-1.803154	1	-2.033876	1	0.619694	0		
	5%	-1.803154	1	-2.033876	1	0.619694	1	1	BE
	10%	-1.803154	1	-2.033876	1	0.619694	1		
Canada	1%, 5% , 10%	-0.865329	1	-1.311193	1	1.842874	1	1	CA
Switzerland	1%, 5% , 10%	-1.558616	1	-2.441944	1	0.791005	1	1	CH
Germany	1%	-2.720918	1	-2.862288	1	0.809339	1		
	5.05%	-2.720918	1	-2.862288	1	0.809339	1	1	DE
	10%	-2.720918	0	-2.862288	0	0.809339	1		
Denmark	1%	-1.451946	1	-3.013181	1	1.947964	1		
	5%	-1.451946	1	-3.013181	0	1.947964	1	1	DK
	10%	-1.451946	1	-3.013181	0	1.947964	1		
Spain	1%, 5% , 10%	-1.588452	1	-1.527099	1	2.006951	1	1	ES
Finland	1%, 5% , 10%	-1.550742	1	-1.551529	1	2.048697	1	1	FI
France	1%, 5% , 10%	-1.465265	1	-1.436948	1	1.583275	1	1	FR
Ireland	1%, 5% , 10%	-1.615835	1	-1.371399	1	2.082326	1	1	IE
Italy	1%, 5% , 10%	-2.009675	1	-1.48587	1	1.859323	1	1	IT
Japan	1%, 5% , 10%	-2.135208	1	-1.442833	1	2.016307	1	1	JP
Netherlands	1%	-2.849552	1	-3.281771	1	0.898908	1		
	5%	-2.849552	1	-3.281771	0	0.898908	1	1	NL
	10%	-2.849552	1	-3.281771	0	0.898908	1		
Norway	1%, 5% , 10%	-2.129171	1	-2.19794	1	1.445042	1	1	NO
New Zealand	1%, 5% , 10%	-1.40975	1	-1.313635	1	1.44314	1	1	NZ
Portugal	1%, 5% , 10%	-1.605298	1	-0.63182	1	1.918611	1	1	PT
Sweden	1%	-2.173369	1	-2.628851	1	1.304636	1		
	5%	-2.173369	1	-2.628851	1	1.304636	1	1	SE
	10%	-2.173369	1	-2.628851	0	1.304636	1		
United Kingdom	1%, 5% , 10%	-2.509148	1	-2.405217	1	0.822712	1	1	UK
United States	1%, 5% , 10%	-0.322426	1	0.185989	1	0.795613	1	1	US

Unit root tests are done assuming exogenous constant to regression equation, lag length has been chosen in guidance with Schwarz Information Criteria.
All the unit root tests have been estimated using Eviews 8.0 software. Interest series are represented by log(MMR)

ADF test results for all countries' interest rate series are evident in favour of null hypothesis for series containing one unit root at 5% significance level. For the robustness checks of the results it has been decided to run Phillips-Perron unit root test as it corrects for serial correlation bias. The of all ADF tests have been supported by the Phillips-Perron tests at 5% significance level except for interest rates of Denmark and Netherlands. For these countries, the test results of interest rates are suggestive of stationarity of the series. Additional Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests have been run. The null hypothesis of the test is reverse of that of ADF and Phillips-Perron tests – stationarity of the series is assumed. Running tests with inverse null hypotheses helps to minimise associated Type I and Type II errors. KPSS tests results are suggestive of series containing one unit root for all countries except Belgium where stationarity of the series has been detected.

Need for most series differencing has been indicated by all tests run. For countries interest rates where no unique result has been identified by the various tests run, it has been decided to “settle with the majority”. From that concluding that all the series are differenced to become stationary.

6.1.2 Data descriptive statistics and normality tests.

Interest rate series that are used for further volatility estimation are differenced logarithm of money market rate. Logarithm transformation together with the induced stationarity resulted with observation loss. The drawback of missing values has been experienced for a number of countries - Switzerland (9 observations loss), Denmark (4), France (4), Ireland (21), Japan (2) and Norway (3). As data samples for those countries ranges from 430 to 648 overall observations, number of missing data is negligible. So it has been decided not to alter any derivation techniques used so far. Instead to make series of continuous frequency and to compensate for missing values generated it has been decided to interpolate them. The continuity of the series is essential for further volatility estimations, for both parametric and non-parametric techniques.

Linear interpolation has been applied to the series of Switzerland, Denmark, France, Ireland, Japan and Norway. Linear interpolation has been done using EViews 8 software, where the missing value is obtained by the means of average from the appropriate end points. Linear interpolation has been chosen as optimal technique as it should smooth series and avoids any misspecification problem in further tests.

One of the simplest measures of volatility is the standard deviation. Standard deviation for the series is reported in Table 6-2 together with the rest of the descriptive statistics and normality test results. We are not using standard deviation measure in our analysis, as it is too primitive from an econometrics point of view (for further discussion please see Measuring exchange rate volatility section). However, for illustrative purposes of volatility it is a good indicator. Series with the largest standard deviation of interest rate are those of Switzerland (51.67 level points) and the smallest of Finland (6.66 level points). Comparatively large standard deviation value for Switzerland’s interest rate series could be consequence of outliers present in the data. As most of the results are distributed within the range of -170.29 to -248.49, the global maxima and minima of the series could be outliers and not representative of the day-to-day volatility of the series. Removal of observations for December 1980 (-364.55) and January 1981 (279.12) would have reduced standard deviation measure to the level of 46.8 points.

Not surprisingly, Switzerland's data range is the largest among interest rate series and is of 643.67 level points. Removal of endpoints would have reduced it to 418.76 level points. Smallest data range for interest rate series belongs to Italy with the value of 63.79 point, which is more than 10 times less than that of Switzerland.

Table 6-2 Descriptive statistics and normality tests of interest rate series

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
Austria	-0.30	0.00	44.18	-66.88	9.34	-0.37	11.60	1667.04	0.00
Australia	0.01	0.00	65.22	-73.97	8.15	-0.55	25.14	10380.51	0.00
Belgium	-0.42	0.00	71.38	-71.33	12.23	0.16	13.54	2044.07	0.00
Canada	-0.15	0.00	73.89	-100.55	15.54	0.14	9.01	977.60	0.00
Switzerland	-1.90	0.00	279.12	-364.55	51.67	-0.83	13.27	1939.52	0.00
Germany	-0.24	0.00	165.17	-93.99	17.50	1.23	23.68	11219.82	0.00
Denmark	-0.35	-0.28	175.35	-239.68	24.00	-1.15	33.37	18438.72	0.00
Spain	-0.39	0.00	125.73	-102.76	18.67	-0.26	13.09	1925.56	0.00
Finland	-0.66	-0.07	34.33	-41.31	6.66	-0.72	10.51	990.29	0.00
France	-0.15	-0.30	33.16	-30.63	6.77	0.20	7.92	581.34	0.00
Ireland	-0.44	0.00	105.96	-100.91	12.76	0.16	30.04	14475.90	0.00
Italy	-0.17	-0.11	45.63	-28.57	7.07	1.14	11.27	1499.16	0.00
Japan	-0.66	0.00	230.01	-167.43	24.89	1.84	36.15	30034.67	0.00
Netherlands	-0.27	0.00	226.75	-144.69	23.98	2.14	34.67	26422.66	0.00
Norway	-0.16	0.00	62.84	-100.22	15.39	-1.32	13.52	2371.62	0.00
New Zealand	-0.58	0.00	119.88	-135.13	12.90	-1.04	62.14	46842.40	0.00
Portugal	-0.74	-0.58	60.84	-66.88	12.00	0.21	10.24	755.29	0.00
Sweden	-0.19	0.00	184.18	-160.25	20.79	0.83	37.23	26922.22	0.00
United Kingdom	-0.40	0.00	168.64	-167.96	24.93	0.83	26.75	11262.78	0.00
United States	-0.60	0.17	81.09	-91.11	11.50	-1.41	23.19	11216.45	0.00

All the data descriptive statistics and normality tests have been estimated using Eviews 8.0 software
Interest rate series are approximated by 100D[log $(MMR)_t$]

Negative mean values for most of the series indicate that on average over the past five decades money market rate has decreased, with the only one exception. Interest rate for Australia has slightly increased over the period of August 1969 to October 2011 by 0.01 level points. Median for most of the series is zero with a few exceptions for Denmark, Finland, France, Italy, Portugal and the United States. Still their values are very close to zero.

Large Jarque-Bera Statistics are suggestive of non-normality of series that is confirmed by the corresponding p-values. Followed by rejection of the Null hypothesis for the test of Normal distribution with third moment equal to 0 and fourth being equal to 3. These all have been confirmed by the estimated third and fourth moments of the series distributions, where results are far from ideal. The closest skewness coefficient can get to 0 is at 0.14 level for Canada, the smallest kurtosis can reach a value of 7.92 for France.

6.1.3 Rolling standard deviation model of interest rate volatility

From non-parametric measures our choice has fallen onto rolling standard deviation measure, as it is one of the most sophisticated techniques. It is superior to usual standard deviation, as it is time varying (for further comparison of the volatility models please refer to Measuring exchange rate volatility section).

Volatility measure has been estimated with a choice of 12 lags for the lag length order as series are in monthly frequency. Descriptive statistics of the series is present in the last subsection.

6.1.4 GARCH(1,1) measure of interest rate volatility

Before any general autoregressive conditional heteroskedasticity models can be fitted, we need to run tests for the detection of autoregressive conditional heteroskedasticity effects. The Lagrange Multiplier test is run on residuals from the general specification of the series, where exogenous constant variable is included. The test statistics, F-test and nR^2, are compared to critical values of F-statistic and Chi squared distribution with one degree of freedom. As series are in monthly frequency, lag length for the test has been chosen at 1, 6 and 12. Results of the tests are reported in Table 6-3.

Table 6-3 ARCH LM tests for interest rate series

	K=1			K=6			K=12		
	F stat	TR^2	Presence of ARCH effects	F stat	TR^2	Presence of ARCH effects	F stat	TR^2	Presence of ARCH effects
AT	5.751173	5.711204	YES	8.399841	46.59112	YES	4.936356	54.44164	YES
AU	123.8726	99.82846	YES	29.13832	130.9597	YES	15.61278	138.5515	YES
BE	71.73695	64.7571	YES	21.31757	107.6349	YES	11.92471	118.7962	YES
CA	44.0368	40.1965	YES	9.490904	51.08051	YES	5.258537	56.50346	YES
CH	98.24295	79.78454	YES	22.50132	101.7096	YES	10.62126	96.96553	YES
DE	47.16418	43.96176	YES	9.145005	50.90752	YES	5.931648	64.97271	YES
DK	107.6556	87.9308	YES	44.57675	170.9023	YES	21.87026	168.7137	YES
ES	36.24904	33.69583	YES	20.33857	97.05516	YES	12.39509	113.7335	YES
FI	49.91767	44.63649	YES	7.925204	43.1743	YES	4.226292	46.2849	YES
FR	59.12941	53.71703	YES	12.76088	68.0645	YES	6.296431	67.77742	YES
IE	293.684	178.0302	YES	98.38237	251.8324	YES	51.77549	252.3301	YES
IT	47.93529	43.81134	YES	17.10752	85.67875	YES	9.18688	91.57402	YES
JP	13.37769	13.14545	YES	4.198461	24.48815	YES	5.630034	62.11208	YES
NL	24.48697	23.62993	YES	41.07994	177.4003	YES	27.27372	215.8775	YES
NO	29.22937	27.65716	YES	11.56543	61.24498	YES	10.74476	102.8459	YES

NZ	116.7315	85.92446	YES	6.626946	36.01584	YES	3.838909	41.61371	YES
PT	2.294041	2.292082	NO	3.995757	22.83132	YES	2.434157	27.854	YES
SE	228.1732	161.5988	YES	56.73702	211.0611	YES	28.5178	212.3017	YES
UK	41.30961	38.15837	YES	24.62076	113.7412	YES	13.2837	121.2341	YES
US	196.6936	151.1961	YES	43.28703	186.3614	YES	30.70037	236.3367	YES

Conclusion to the presence of ARCH effects based on both F-test and TR^2 has been drawn at 5% significance level

All tests were run using EViews 8.0 software

Heteroskedasticity in the residuals has been detected for all countries' series at higher lags of length 6 and 12. At lag length of 1 no ARCH effects have been found in interest rate series' residuals for Portugal. For the rest of the series, results are suggestive of the need for ARCH based measure fittings for volatility. In the case of Portugal, we assume the need for conditional heteroskedasticity based volatility modelling as volatility has been detected at higher lag length order.

There are no tests aimed at detecting GARCH effects, so to show superiority of GARCH (1,1) model to ARCH (1) likelihood ratio tests are run. Likelihood ratio tests have been previously used to compare GARCH based models in research (e.g. Wang et al. (2001), Grier and Grier (2006)). ARCH (1) model is a restricted version of a more general GARCH (1,1) model where GARCH term's coefficient is set equal to zero. Maximums of log likelihood functions are obtained from running appropriate ARCH/GARCH based regressions. ARCH/GARCH based regressions run under assumption of Normal–Gaussian distribution. Normality tests have shown that normality of the residuals series is questioned together with the assumption of series following Normal distribution. Bollerslev – Wooldridge heteroskedasticity consistent covariance and standard errors have been specified for the robust results independently of the distribution chosen. EViews 8 software has been used to estimate Log likelihood statistics. Likelihood ratio test statistic is then constructed as difference of maximum log likelihood functions for restricted and unrestricted models and multiplied by a scalar of minus two. This value is then compared to the appropriate Chi squared critical value with one restriction and at 1% significance level. Likelihood ratio tests results are reported in Table 6-4.

Table 6-4 Likelihood ratio tests

	Log-L Restricted	Log-L Unrestricted	LR statistic	Chi^2(1), 1% s.l.	Models Chosen
AT	-1929.134	-1838.225	181.818	6.635	GARCH(1,1)
AU	-1740.789	-1597.689	286.200	6.635	GARCH(1,1)
BE	-2618.429	-2528.079	180.700	6.635	GARCH(1,1)
CA	-1690.707	-1646.537	88.340	6.635	GARCH(1,1)
CH	-2245.432	-2185.845	119.174	6.635	GARCH(1,1)

DE	-2464.043	-2264.666	398.754	6.635	GARCH(1,1)
DK	-1885.617	-1769.064	233.106	6.635	GARCH(1,1)
ES	-1826.508	-1669.433	314.150	6.635	GARCH(1,1)
FI	-1298.046	-1275.805	44.482	6.635	GARCH(1,1)
FR	-1866.627	-1856.438	20.378	6.635	GARCH(1,1)
IE	-1726.459	-1719.543	13.832	6.635	GARCH(1,1)
IT	-1524.567	-1507.131	34.872	6.635	GARCH(1,1)
JP	-2788.377	-2445.444	685.866	6.635	GARCH(1,1)
NL	-2410.793	-2319.233	183.120	6.635	GARCH(1,1)
NO	-1825.060	-1825.060	0.000	6.635	GARCH(1,1)
NZ	-1069.730	-1037.594	64.272	6.635	GARCH(1,1)
PT	-1305.705	-1236.671	138.068	6.635	GARCH(1,1)
SE	-2263.145	-2162.980	200.330	6.635	GARCH(1,1)
UK	-2101.453	-1872.515	457.876	6.635	GARCH(1,1)
US	-2292.279	-2198.984	186.590	6.635	GARCH(1,1)

Test results are evident of GARCH(1,1) superiority to the ARCH (1) model by a large margin. It does not come as a surprise because GARCH(1,1) model is advanced to ARCH(1) structurally.

6.1.5 Asymmetric GARCH based interest rate volatility measures

Interest rates are financial instruments that reflect elements of the financial mechanism such as the higher the default risk and its probability – the higher is the risk premium (the higher are the interest rates) and vice versa. However, interest rates are not moving freely in the market as they are tied in with the base rate that is predetermined by Central Bank. Central Banks use interest rates to track inflation by influencing money supply in the economy to aid in achieving monetary policy objectives. All of interest rate formation interventions could make volatility of the series asymmetrical dependant on the target.

During recent financial crisis, for example, Central bank in the UK reduced the interest rate to 0.5%, in order to encourage spending and increase private consumption, and potentially to reduce inflation rates winding up. This creates a situation where market conditions were violated in the public interest. So higher interest rates, that are supposed to be associated with higher risk bearing, were set at lower levels. Adverse shock to economy created lower interest rates that have been artificially held at the same level for some time to avoid deflation tendencies. This comes in opposition with Central Bank policies during positive shocks to economy. In times of economic boom banks will be vice versa encouraged to increase base rates, so diverting people from increased borrowing and spending, thus encourage them to save more, in order to avoid an inflation rise. Financial market players react to negative and positive shocks differently as well. Economic downturns and higher volatility create more opportunities for speculative profits. Whereas times of positive aftershock bear less risk and return, so create less market volatilities and decrease the chances of abnormal profits. The GARCH model has ignored distinction in response of conditional heteroskedasticity to direction and magnitude of a shock.

It is not possible to account for asymmetries in the GARCH traditional model as its variance equation is assumed to be symmetric. In order to find whether interest rate series possess asymmetrical properties in conditional heteroskedasticity structure we need to investigate further.

Engle and Ng (1993) propose joint asymmetries test for sign and size bias of the series. Test has been performed using EViews 8.0 software, as there is no automatic option for the test so test has been done manually in a few steps. First, GARCH (1,1) model has been run for the interest rate series and residuals collected. Then two dummy variables are created, one to indicate negative values of the previous period residual, second is restricted to positive values of the previous period residual. Then regression is run of squared residuals from the GARCH model on constant, negative dummy variable, multiple of negative dummy variable by previous period residual and multiple of positive dummy by previous period residual. Results from the regression are presented in Table 6-5, where sign bias represents coefficients of negative dummy variable, negative and positive size bias represent coefficients of negative and positive multiples of previous period residuals accordingly. In parenthesis below the coefficient values – associated p-values are present. The LM Statistic nR^2 helps to test null hypothesis of all coefficients jointly equal to zero. Critical test value is 11.345 and is determined by chi-squared distribution with 3 degrees of freedom and at 1% significance level. The non-rejection of null hypothesis indicates presence of asymmetries that has to be accounted for in variance modelling. Presence of asymmetric effects has been confirmed by the joint test for all countries.

Table 6-5 Engle and Ng(1993) test for the presence of asymmetries

	sign bias	negative size bias	positive size bias	no. of observations	R^2	nR^2	Presence of asymmetric effects
AT	-31.61138	-10.85962	1.327090	536	0.044847	24.037992	YES
	(0.3002)	(0.0000)	(0.5678)				
AU	-57.99115	-23.00893	5.059439	506	0.137669	69.660514	YES
	(0.1071)	(0.0000)	(0.1161)				
BE	-5.057546	-21.98728	17.26550	647	0.120151	77.737697	YES
	(0.9384)	(0.0000)	(0.0000)				
CA	11.82421	-20.81366	8.569939	440	0.101431	44.62964	YES
	(0.8440)	(0.0000)	(0.0142)				

CH	-1511.056 (0.1377)	-97.95240 (0.0000)	67.67454 (0.0000)	429	0.154164	66.136356	YES
DE	-346.6290 (0.0049)	-65.30374 (0.0000)	8.438025 (0.0699)	620	0.205016	127.10992	YES
DK	-464.5624 (0.1303)	-92.78573 (0.0000)	27.15577 (0.0043)	476	0.216783	103.188708	YES
ES	12.48373 (0.9229)	-27.36346 (0.0000)	24.56365 (0.0000)	452	0.11442	51.71784	YES
FI	-49.12830 (0.0027)	-14.26990 (0.0000)	1.312131 (0.4846)	405	0.173225	70.156125	YES
FR	-2.519903 (0.8423)	-7.386995 (0.0000)	6.600324 (0.0000)	572	0.089572	51.235184	YES
IE	96.21371 (0.2017)	-36.76854 (0.0000)	57.05315 (0.0000)	474	0.359546	170.424804	YES
IT	-34.99795 (0.0488)	-15.68153 (0.0000)	9.574680 (0.0000)	488	0.169174	82.556912	YES
JP	-187.5883 (0.5431)	-63.97277 (0.0000)	17.49707 (0.0253)	647	0.073779	47.735013	YES
NL	-276.5643 (0.3232)	-77.15005 (0.0000)	40.84453 (0.0000)	620	0.137714	85.38268	YES
NO	-37.72124 (0.6720)	-16.93690 (0.0000)	22.49911 (0.0000)	483	0.088116	42.560028	YES
NZ	568.3942 (0.0000)	-3.330129 (0.5009)	138.5804 (0.0000)	320	0.648799	207.61568	YES
PT	61.89025 (0.2815)	-8.326120 (0.0179)	6.495950 (0.0474)	344	0.035321	12.150424	YES
SE	-414.8496 (0.0662)	-87.31488 (0.0000)	61.28307 (0.0000)	549	0.279162	153.259938	YES
UK	-175.2759 (0.5630)	-77.29594 (0.0000)	25.00577 (0.0023)	476	0.155298	73.921848	YES
US	-145.5489 (0.0032)	-43.47126 (0.0000)	5.994263 (0.1007)	647	0.314035	203.180645	YES

Sign bias coefficient is negative for most of the series (15 out of 20) suggesting that negative shock is resulted in reduction of the next period squared residual subsequently conditional variance. For Canada, Spain, Ireland, New Zealand and Portugal sign bias coefficient is positive indicating that negative shock will be pushing up conditional variance for the following period. However, sign bias for interest rate residuals is rarely significant. Its significance at 10% level for Germany, Finland, Italy, New Zealand, Sweden and US is evident of asymmetries in volatility reaction to positive and negative shocks.

Negative and positive size bias indicators measure whether positive and negative shocks effect on variance is differentiated according to the shock magnitude. Negative size bias coefficients are highly significant with p-values of zero for most of the series except for Portugal, where significance level is of 1.79% and New Zealand where p-value jumps above 0.5. Coefficient of the indicator is negative for all countries' series being evident of inverse relationship between past shock and current period variance. For positive size bias relationship between variance and previous period positive shock element is less significant, still at 10% significance level coefficient is significant for 16 out of 20 countries' series. Previous period positive shocks tend to increase volatility of the series, as evident from the positive coefficients estimated by regression analysis. From asymmetry detection analysis it can be concluded that negative size bias is the strongest driver behind the asymmetries.

Potentially a number of asymmetric GARCH models have been chosen to fit the data. First of all we thought of GJR–GARCH model, because it models variance in such a way that negative past shocks have larger impact on volatility, as an additional term enters variance equation. This additional term represents a multiplication of dummy variable for negative last period residual and current period squared "ARCH" residual. Advantage of these tests is that they give more weight in variance modelling to negative past shocks, the importance of which has been emphasised by the results of Engle and Ng (1993) tests for the data.

Table 6-6 Log likelihood tests for asymmetric GARCH models

	Log-L GARCH(1,1)	Log-L GJR-GARCH(1,1)	Log-L QGARCH(1,1)	Log-L PARCH(1,1)	LR1	LR2	LR3	Chi^2(1), 1% s.l.	Models Chosen
AT	-1838.225	-1831.645	-1833.026	-1831.700	13.160	10.398	13.050	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
AU	-1597.689	-1594.538	-1583.636	-1594.435	6.302	28.106	6.508	6.635	GARCH(1,1), QGARCH(1,1)
BE	-2528.079	-2523.159	-2522.505	-2523.074	9.840	11.148	10.010	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
CA	-1646.537	-1605.104	-1606.098	-1605.006	82.866	80.878	83.062	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
CH	-2185.845	-2167.763	-2164.882	-2168.908	36.164	41.926	33.874	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
DE	-2264.666	-2254.038	-2255.127	-2253.764	21.256	19.078	21.804	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
DK	-1769.064	-1768.682	-1762.859	-1768.686	0.764	12.410	0.756	6.635	GARCH(1,1), QGARCH(1,1)
ES	-1669.433	-1668.850	-1664.678	-1668.821	1.166	9.510	1.224	6.635	GARCH(1,1), QGARCH(1,1)
FI	-1275.805	-1273.732	-1264.752	-1273.859	4.146	22.106	3.892	6.635	GARCH(1,1), QGARCH(1,1)
FR	-1856.438	-1855.124	-1841.408	-1855.195	2.628	30.060	2.486	6.635	GARCH(1,1), QGARCH(1,1)
IE	-1719.543	-1719.466	-1714.515	-1719.458	0.154	10.056	0.170	6.635	GARCH(1,1), QGARCH(1,1)
IT	-1507.131	-1502.817	-1493.946	-1502.892	8.628	26.370	8.478	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
JP	-2445.444	-2437.778	-2435.726	-2437.820	15.332	19.436	15.248	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
NL	-2319.233	-2308.506	-2315.410	-2308.510	21.454	7.646	21.446	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
NO	-1825.060	-1813.047	-1806.508	-1813.059	24.026	37.104	24.002	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
NZ	-1037.594	-1037.429	-1028.398	-1037.387	0.330	18.392	0.414	6.635	GARCH(1,1), QGARCH(1,1)
PT	-1236.671	-1235.971	-1231.649	-1235.925	1.400	10.044	1.492	6.635	GARCH(1,1), QGARCH(1,1)
SE	-2162.980	-2149.379	-2145.540	-2149.313	27.202	34.880	27.334	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
UK	-1872.515	-1856.449	-1845.719	-1856.540	32.132	53.592	31.950	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)
US	-2198.984	-2192.547	-2187.314	-2192.401	12.874	23.340	13.166	6.635	GJR-GARCH(1,1), QGARCH(1,1), PARCH(1,1)

Second model of interest is Quadratic GARCH model. Its distinction from the traditional GARCH model is additional previous period residual in variance specification. This makes QGARCH model more flexible compared to GJR as both positive and negative previous period shocks will have impact on volatility of the series. Impact will be differentiable not only by sign of the previous shock but by magnitude as well. Thus two asymmetric models will be considered to model volatility of the series. As a benchmark to see that conditional variance is not over-fitted we will be using GARCH series as an alternative.

We have seen GJR–GARCH model where only adverse shock has additional impact on volatility, we have seen models where positive and negative shocks have different impacts on volatility. But what if sign of the shock does not matter, but its magnitude does? So we have decided to add PARCH (1,1) model to the list with fixed parameter of 2. It gives us model with variance specification close to that of QGARCH except that it is not the actual previous residual that has been added to the equation, but its absolute value. This model assumes that any previous period shock, indifferent of its sign, but proportionally to its magnitude has cumulative effect on volatility.

Likelihood ratio tests have been conducted to test what models will be better fit for the countries data. Overall four volatility models have been estimated in Eviews 8.0. For all models it has been assumed that they follow Normal distribution and Bollerslev-Wooldridge heteroskedasticity consistent covariance has been estimated. Maximum Log-likelihood statistics have been collected from the regression analysis. Then tests have been run, where it was assumed that GARCH (1,1) model is the restricted model for all three tests. Unrestricted models for tests 1,2 and 3 are for GJR-GARCH (1,1) model with threshold value of 1,and QGARCH (1,1), PARCH (1,1) with fixed power parameter of 2. In contrast to the rest of the models, one less term in variance equation chi-squared critical value has been chosen with one degree of freedom for the GARCH(1,1) model. Results of the tests together with the models chosen have been presented in Table 6-6.

According to the likelihood ratio tests, in particular test 2, QGARCH (1,1) model has been the most universal fit, as it has been chosen over GARCH (1,1) model for all the countries. As we can see from p-values in Table 6-5, popularity of the QGARCH series is justified and the magnitude of a shock is more important than the sign of it. For 12 countries out of 20 volatility fitting of GJR-GARCH (1,1) and PARCH (1,1) has been chosen over GARCH (1,1) models. For conditional variance of Australia, Denmark, Spain, Finland, France, Ireland, New Zealand and Portugal, GJR-GARCH (1,1) and PARCH (1,1) variance modelling did not appear to be a beneficial specification alteration.

6.1.6 *Volatility measures: summary and descriptive statistics.*

A number of volatility models have been chosen for interest rate series. Firstly, from non-parametric models of volatility rolling standard deviation has been chosen with the lag length of 12. Secondly, from parametric series we had to make a choice of 2-3 models from GARCH (1,1), GJR-GARCH (1,1), QGARCH (1,1) and PARCH (1,1) according to the series econometric nature. Once models have been estimated their frequency has been converted to yearly (where on the endpoints number of observations was not sufficient, i.e. less than 12, those data points were trimmed off). Final measures' choice together with its statistical properties is presented in Table 6-7, and the associated volatility measures have been plotted by country in Appendix A5.

On the first glance at the graphs it is easy to notice (from their scaling) that standard deviation based volatility measures have smallest range. For all countries, rolling standard deviation has lowest mean, minimum, maximum and standard deviation values. This can be supported by figures in Table 3-1. From here, we can see that on average the most volatile of the variables is IRV2, which is a mix of GARCH and GJR-GARCH volatility measures. It also has highest mean and minimum and maximum values. Once we have a more detailed look at the measures within countries then the picture changes substantially.

For Austria and the United States, GJR-GARCH volatility measure has largest mean and maximum values. Consequently, these models are the most volatile according to standard deviation values. Similarly, GARCH based models have largest mean, maximum and standard deviation results for Australia and Finland. For Germany, Denmark, Spain, France, Great Britain, Ireland, Japan, Netherlands, New Zealand and Portugal, measure with highest volatility, average and peak values is QGARCH and for the rest of the countries it is PARCH.

Table 6-7 Descriptive statistics and normality tests of yearly volatility measures of interest rate series

	Number of observations	**Mean**	**Median**	**Maximum**	**Minimum**	**St.Deviation**	**Skewness**	**Kurtosis**	**Jarque –Bera statistic**	**Jarque-Bera p-value**
Austria (AT)										

MA12	43	0.57	0.47	1.32	0.11	0.35	0.80	2.53	4.93	0.09
GJR-GARCH (1,1)	43	8.30	4.88	69.44	0.91	11.78	3.64	18.33	515.85	0.00
QGARCH (1,1)	43	7.96	4.73	52.93	0.88	9.66	2.83	12.44	216.91	0.00
PARCH (1,1)	43	8.29	4.87	69.32	0.91	11.76	3.64	18.30	514.36	0.00
Australia (AU)										
MA12	40	0.49	0.33	2.47	0.08	0.44	2.45	11.22	152.51	0.00
GARCH(1,1)	41	6.70	2.92	80.77	0.37	12.88	4.83	28.10	1236.17	0.00
QGARCH (1,1)	41	6.52	3.22	78.95	0.21	12.54	4.90	28.61	1284.01	0.00
Belgium (BE)										
MA12	53	1.00	0.99	3.04	0.08	0.69	0.99	3.99	10.88	0.00
GJR-GARCH (1,1)	53	21.70	13.83	118.83	1.29	25.33	2.32	8.41	112.07	0.00
QGARCH (1,1)	53	21.60	14.09	110.07	0.79	24.66	2.26	7.95	99.07	0.00
PARCH (1,1)	53	21.71	14.03	118.90	1.28	25.34	2.32	8.42	112.34	0.00
Canada (CA)										
MA12	35	0.75	0.57	2.21	0.16	0.55	1.41	3.95	12.98	0.00
GJR-GARCH (1,1)	35	14.78	7.38	146.44	1.30	25.47	4.19	21.78	616.66	0.00
QGARCH (1,1)	35	13.35	7.45	77.41	1.14	17.25	2.25	7.50	59.08	0.00
PARCH (1,1)	35	14.81	7.39	147.01	1.29	25.56	4.20	21.83	619.72	0.00
Switzerland (CH)										
MA12	34	3.16	2.63	13.02	0.52	2.63	1.70	6.73	36.14	0.00
GJR-GARCH (1,1)	35	367.9	134.04	2777.7	11.15	592.37	2.55	9.61	101.62	0.00
QGARCH (1,1)	35	313.5	133.14	2551.8	10.97	478.64	3.21	14.86	265.42	0.00
PARCH (1,1)	35	371.7	128.08	3042.7	12.40	618.17	2.84	11.58	154.50	0.00
Germany (DE)										
MA12	50	0.95	0.48	4.72	0.11	0.99	1.66	5.78	39.08	0.00
GJR-GARCH (1,1)	50	28.30	4.28	261.08	0.66	49.28	2.73	11.63	217.15	0.00
QGARCH (1,1)	50	30.11	4.60	343.33	0.58	58.27	3.59	18.32	596.10	0.00
PARCH (1,1)	50	28.30	4.29	260.38	0.66	49.24	2.71	11.55	213.78	0.00
Denmark (DK)										
MA12	38	1.14	0.41	7.24	0.07	1.50	2.32	8.75	86.49	0.00
GARCH(1,1)	38	62.44	5.05	824.51	0.76	162.83	3.75	16.55	379.75	0.00
QGARCH (1,1)	38	62.74	4.92	852.13	0.80	164.81	3.83	17.30	416.82	0.00
Spain (ES)										
MA12	36	1.00	0.47	4.56	0.10	1.08	1.67	5.38	25.28	0.00
GARCH(1,1)	36	34.46	4.46	333.86	0.45	67.54	3.11	13.08	210.42	0.00
QGARCH (1,1)	36	34.50	4.47	335.11	0.44	67.73	3.12	13.12	211.82	0.00
Finland (FI)										
MA12	32	0.38	0.34	0.86	0.09	0.20	0.65	2.75	2.34	0.31
GARCH(1,1)	33	5.49	3.40	30.46	0.95	6.77	2.83	10.55	122.34	0.00
QGARCH (1,1)	33	5.24	3.24	27.08	0.73	6.11	2.69	9.90	105.20	0.00
France (FR)										
MA12	46	0.42	0.43	1.06	0.09	0.23	0.59	3.13	2.70	0.26
GARCH(1,1)	46	3.78	3.06	14.60	1.99	2.31	2.73	12.04	213.79	0.00
QGARCH (1,1)	46	3.99	3.20	12.06	1.54	2.52	1.41	4.38	18.94	0.00
Great Britain (GB)										
MA12	38	1.31	0.85	7.86	0.23	1.50	2.74	11.22	154.69	0.00
GJR-GARCH (1,1)	38	77.10	13.46	765.03	1.83	175.76	3.11	11.54	176.51	0.00

QGARCH (1,1)	38	80.43	15.51	938.80	1.24	188.02	3.36	14.10	266.82	0.00
PARCH (1,1)	38	77.48	13.50	769.30	1.81	176.64	3.11	11.54	176.58	0.00
Ireland (IE)										
MA12	37	0.68	0.48	4.61	0.14	0.73	4.39	24.32	819.35	0.00
GARCH(1,1)	38	11.24	6.00	112.42	4.45	18.42	4.72	25.65	953.66	0.00
QGARCH (1,1)	38	11.82	6.17	123.45	4.26	20.40	4.69	25.35	930.43	0.00
Italy (IT)										
MA12	39	0.37	0.28	1.09	0.09	0.24	1.33	4.56	15.46	0.00
GJR-GARCH (1,1)	39	4.58	2.32	30.02	1.00	6.41	2.88	10.87	154.50	0.00
QGARCH (1,1)	39	4.35	2.31	24.49	0.86	5.76	2.51	8.35	87.34	0.00
PARCH (1,1)	39	4.58	2.33	30.04	1.00	6.42	2.87	10.86	154.05	0.00
Japan (JP)										
MA12	53	1.11	0.45	5.88	0.08	1.53	1.92	5.29	44.08	0.00
GJR-GARCH (1,1)	53	55.59	5.12	421.65	1.13	114.74	2.23	6.60	72.41	0.00
QGARCH (1,1)	53	850.5	71.71	6440.4	7.34	1776.89	2.13	6.04	60.39	0.00
PARCH (1,1)	53	667.1	61.45	5058.5	13.59	1376.80	2.23	6.60	72.34	0.00
Netherlands (NL)										
MA12	50	1.10	0.55	8.25	0.08	1.54	2.89	12.06	240.37	0.00
GJR-GARCH (1,1)	50	57.52	5.55	860.62	0.90	165.80	4.07	18.94	667.59	0.00
QGARCH (1,1)	50	68.64	6.06	1054.3	0.86	204.16	4.14	19.44	705.86	0.00
PARCH (1,1)	50	57.48	5.55	859.87	0.90	165.66	4.07	18.94	667.52	0.00
Norway (NO)										
MA12	38	0.90	0.59	3.28	0.14	0.78	1.37	4.20	14.22	0.00
GJR-GARCH (1,1)	39	29.78	7.33	160.00	1.29	41.18	1.75	5.30	28.45	0.00
QGARCH (1,1)	39	28.22	6.65	167.66	1.53	40.75	1.97	6.21	42.03	0.00
PARCH (1,1)	39	29.86	7.35	160.58	1.29	41.27	1.74	5.29	28.27	0.00
New Zealand (NZ)										
MA12	25	0.53	0.42	1.64	0.09	0.42	1.01	3.16	4.31	0.12
GARCH(1,1)	25	6.56	2.39	24.55	0.62	7.81	1.27	3.07	6.73	0.03
QGARCH (1,1)	25	6.74	2.56	24.23	0.51	8.01	1.21	2.90	6.15	0.05
Portugal (PT)										
MA12	27	0.69	0.40	1.81	0.12	0.54	0.80	2.21	3.60	0.17
GARCH(1,1)	27	12.26	4.38	48.14	1.09	14.46	1.26	3.22	7.16	0.03
QGARCH (1,1)	27	12.95	4.77	48.73	0.85	15.44	1.23	3.09	6.76	0.03
Sweden (SE)										
MA12	44	1.00	0.62	6.79	0.14	1.25	2.95	12.62	233.61	0.00
GJR-GARCH (1,1)	45	98.15	14.36	1131.2	3.82	261.15	3.37	12.77	263.84	0.00
QGARCH (1,1)	45	71.64	13.93	791.30	3.92	181.72	3.38	12.88	268.42	0.00
PARCH (1,1)	45	98.34	13.76	1133.8	3.82	261.73	3.37	12.77	263.83	0.00
United States (US)										
MA12	53	0.58	0.41	2.96	0.11	0.58	2.34	8.48	114.81	0.00
GJR-GARCH (1,1)	53	13.99	3.67	151.34	1.47	31.54	3.39	13.44	342.38	0.00
QGARCH (1,1)	53	12.59	3.58	133.7	1.54	27.29	3.41	13.66	353.70	0.00
PARCH (1,1)	53	13.89	3.65	151.1	1.47	31.31	3.41	13.55	348.45	0.00

6.2 Interest Rate Volatility effect on labour market performance.

The interest rate volatility effect on labour market performance is the least researched area out of the three topics that are covered by this thesis. Lack of research in the area gives advantage of being among the first in the field and disadvantage of not being able to discuss and compare this study to results in the literature. Based on literature review of indirect effect in Chapter 2, we believe that uncertainty has negative effect on labour market performance. Similarly to exchange rate uncertainty, the interest rate uncertainty can increase job destruction rates, however it might have impact on job creation rates as well. Looking back at the theoretical model Belke and Gross (2001) interest rate can be incorporated to the theoretical model by introducing the discount rate into present value analysis. Then volatility in interest rate not only will create uncertainty in production process, but in the alternative investment process too. This uncertainty may decrease opportunity cost of capital, and thus increase the job creation rates. However, we expect the net impact of uncertainty on labour market performance to be adverse, as positive effect on job destruction would be higher than possible effect on job creation.

On the practical side, four volatility measures have been selected for the analysis and a number of alternative specification tests are outlined. First of all, optimal baseline model is to be derived. Here a number of alterations to fit best panel data method among those available have been done. Following logic of previous empirical research and the fact that volatility measures are integrated of order one, panel time series approach has been employed. Secondly, an attempt to draw a bigger picture of mechanism behind volatility effect on labour market performance has been made. Other than traditional measures of labour market performance, such as employment and unemployment rates have been used. Thirdly, using a number of alternative labour market indicators will test this model for different participating groups. Here in search of asymmetries of the volatility effect on labour market performance, participants have been divided into groups by age, sex, educational attainment and mode of employment.

On the technical side, please note that for all econometric analysis in this section STATA SE 13.1 software has been used.

6.2.1 Unemployment rate determination: Baseline Model derivations

Starting with the baseline model introduction, traditional and probably most common labour market performance indicator is to be used – the unemployment rate. On the side of regressors', following models proposed by Nickell (1998) and Bassanini and Duval (2006 a and b), a number of regressors have been chosen accordingly with volatility variable addition. Explanatory variables are output gap, tax wedge, interest rate volatility, product market regulation, employment protection legislation, average benefit replacement rate and union density. Regression of the model is depicted below:

$$U_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it},$$

where X_{it} represents explanatory variables, α_i accounts for the country effects, d_t abbreviates for time dummies, and u_{it} is an idiosyncratic error. Please note that time dummies that are included in the model are for the USSR collapse (1991), introduction of euro currency (2002) and financial crisis (2008). Before any panel specific technique will be employed, one needs to make sure that simple pooled OLS is not a suitable model. Models' over fitting with imposition of assumptions and restrictions will be avoided here and used only if it appears theoretically justifiable and supported by the relevant diagnostic tests. Pooled OLS model has been estimated assuming clustering of the data within panels.

Table 6-8 Determinants of unemployment for OECD countries (1985-2011): including interest rate volatility indicator

	Pooled OLS (clustered by country)	Fixed effects with AR(1) disturbance	Random effects with AR (1) disturbance	Pooled OLS with Driscoll-Kraay S.E.	Fixed Effects with Driscoll-Kraay S.E.
Interest rate volatility (IRV1)	-0.744***	0.064	0.037	-0.744***	-0.088
Standard error of interest rate volatility coefficient	0.233	0.066	0.068	0.117	0.075
Output gap	-0.547***	-0.321***	-0.344***	-0.547***	-0.534***
Tax wedge	0.144***	0.035**	0.038***	0.144***	0.136***
Product market regulation	0.748	0.108	0.015	0.748***	0.279
Employment protection policies	-0.388	-0.617	-0.323	-0.388***	0.825
Average benefit replacement rate	0.010	-0.024	-0.006	0.010	0.097***
Union density	-0.049	0.257***	0.055**	-0.049***	0.017
Time dummies	YES	YES	YES	YES	YES
R^2 WITHIN		0.476	0.478		0.552
R^2 BETWEEN		0.030	0.000		

R^2 OVERALL	0.352	0.004	0.072	0.352	
WOOLDRIDGE (2002) TEST FOR AUTOCORRELATION	123.25 (0.000)				
AUTOCORRELATION COEFFCIENT		0.903	0.903		
MOD. WALD TEST FOR HETEROSKEDASTICITY[1]		1062.79 (0.000)			
HAUSSMAN TEST[2]		8.70 (0.2751)	8.70 (0.2751)	34.6 (0.000)	34.6 (0.000)
BREUSCH-PAGAN LM TEST[1]	2900.52 (0.000)		2900.52 (0.000)		
PESARAN'S TEST OF CROSS-SECTIONAL DEPENDANCE[1]		3.085 (0.002)			
FRIEDMAN'S TEST OF CROSS-SECTIONAL DEPENDANCE[1]		48.462 (0.000)			
FREE'S TEST OF CROSS-SECTIONAL DEPENDACE[1]		4.060[4]			
AV. NUMBER OF YEARS[3]	24.1	23.1	24.1	24.1	24.1
NUMBER OF COUNTRIES	20	20	20	20	20
NUMBER OF OBSERVATIONS	482	462	482	482	482

Baseline specification for the regressions used is : $U_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$

[1] Tests are done using fixed or random effects accordingly without autoregressive parts.

[2] Hausman test results reported are based on regressions without time effects or time dummies.

[3] Average number of years is used as panel is unbalanced

[4]Associated Q values and its respectful significance levels for the test are 0.1984(10%s.l.), 0.262 (5%s.l.), 0.3901(10%s.l.).

* result is significant at 10% significance level

** result is significant at 5% significance level

*** result is significant at 1% significance level

A first glance at the results, which are displayed in Table 6-8, draws a very optimistic picture. The coefficient of interest rate volatility variable and its respective significance level are very large. If this model holds, then increase in interest rate volatility is accompanied by lower unemployment rate. Shortage of the previous research on the topic area makes it impossible to compare or contrast this result. However, logically this outcome is a possibility. At the literature review chapter it has been discussed that uncertainty tends to lower business activities subsequently associated employment rate. However, possibility of arbitrage and ability to use interest rate to the benefit of business operations can instead lead to a drive to job creation. Still, high significance level together with large value coefficient creates an urge to investigate presence of serial correlation within the model. Incidence of these two elements might be not coincidental. Wooldridge (2002) test confirms these concerns and detects first order autocorrelation at a high significance level. Not only presence of autocorrelation signals about not appropriateness of the model for this scenario, but also there is another fundamental reason. Breusch-Pagan LM test result signal that there is significant difference across countries. Unfortunately, OLS model is too simple and does not account for that.

More sophisticated panel data techniques are needed here, such as fixed and random effects. Taking into account previous autocorrelation concerns, linear models with an AR (1) disturbance within error term have been estimated. Interest rate volatility losses all of its significance according to results. What is more interesting, is that the results difference is striking when choosing between models to employ. Interest rate volatility coefficient produced by fixed effects techniques is twice as big as the one by random effects. Hausman test will help to choose between the models. It looks like Random effects model is preferred as its estimator is efficient according to the test results. But are the test's underlying assumptions of independently and identically distributed errors valid? And subsequently how it affects the optimal estimator choice?

As has been previously demonstrated, the model suffers from first order autocorrelation in the residuals. This already violates baseline assumptions for classic Hausman test. Additionally modified Wald test detects heteroskedasticity in the error terms. How this newly obtained information changes optimal model choice? Hausman test version has been updated accordingly using two similar techniques. First, it is based on Sargan instruments test for over identifying restrictions, and is done on demeaned data based on Wooldridge (2002) and Arellano (1993) proposals. This test is done using STATA module that has been developed and discussed by Schaffer and Stillman (2010). A second technique is similar in a sense to the first one, as it is also based on Wooldridge (2002) auxiliary regression with demeaned data. However rather than Sargan test statistic as in the primary case, this test is based on simple F-statistic. Tests are united in a Fixed Effects model choice, as it produces consistent estimator under the model assumptions. Not all forms of spatial and temporal dependence within the model have been addressed however.

Cross-sectional dependence is common for panel data cases. Three standard tests for cross-sectional dependence have been run – Pesaran, Free's and Friedman's. All of the tests reject null hypothesis of cross-sectional independence. Pooled and fixed effects models have been estimated with Driscoll-Kraay standard errors that are robust to all forms of spatial and temporal dependence including cross-sectional dependence. Results are very mixed depending on the estimator chosen. Pooled OLS results are very similar to the first regression result, however only standard errors change, as they are Driscoll-Kraay. What is surprising is that, as a consequence of such an amendment, all variables became highly significant except for average benefit replacement rate variable. Contrary, fixed effects results are suggestive of interest rate volatility being insignificant in the unemployment rate determination. It applies to the rest of the explanatory variables in the regression model except for output gap, tax wedge and average benefit replacement rate that are indeed highly significant. So which result is the most plausible? Hoechle (2007) provides Wooldridge (2002) test adapted for Dricoll and Kraay standard errors as an alternative to Hausman in the presence of spatial and temporal dependence. Test results are in favour of fixed effects estimator due to its consistency.

6.2.2 Enhanced model of unemployment determination and alternative measures of interest rate volatility

So what conclusions can be drawn so far - interest rate volatility is not related to unemployment rate determination? Not quite, one of the possible problems could be omission of the relevant variables. What is the possible treatment? It has been decided to enhance model with additional variables to include effects of active labour market policies and homeownership rates. Importance of these variables in the unemployment determination model has been addressed by previous research (e.g. Bassanini and Duval (2006a)). Appropriate F-test and R squared statistics will be accounted for to avoid model over fitting. Country fixed effects with Driscoll-Kraay standard errors are used for the estimation.

Table 6-9 Unemployment determination: Enhanced specification with alternative interest rate volatility measures for OECD countries (1985-2011)

	Fixed Effects with Driscoll-Kraay S.E.: Baseline model	Fixed Effects with Driscoll-Kraay S.E.: Enhanced model[1]	Fixed Effects with Driscoll-Kraay S.E.: Baseline model without observations for Switzerland	Fixed Effects with Driscoll-Kraay S.E.: Enhanced model[2]	Fixed Effects with Driscoll-Kraay S.E.: Enhanced model[3]	Fixed Effects with Driscoll-Kraay S.E.: Enhanced model[4]
Interest rate volatility (IRV1)	-0.088	0.243**	-0.029			
Interest rate volatility (IRV2)				0.004***		
Interest rate volatility (IRV3)					0.004***	
Interest rate volatility (IRV4)						0.003***
Standard error of interest rate volatility coefficient	0.075	0.114	0.126	0.001	0.001	0.001
Output gap	-0.534***	-0.503***	-0.528***	-0.507***	-0.507***	-0.508***
Tax wedge	0.136***	0.052	0.132***	0.048	0.048	0.045
Product market regulation	0.279	1.593***	0.357	1.583***	1.583***	1.596***
Employment protection policies	0.825	-2.543**	0.672	-2.473**	-2.473**	-2.380**
Average benefit replacement rate	0.097***	0.026	0.089***	0.033	0.033	0.034
Union density	0.017	0.011	-0.015	0.010	0.010	0.011

Homeownership rate		0.072*		0.079**	0.079**	0.081**
Active labour market policies		-2.137***		-2.078***	-2.079***	-2.043***
Time dummies	YES	YES	YES	YES	YES	YES
Joint F-test [5]		14.00 (0.000)				
R^2 WITHIN	0.552	0.630	0.556	0.639	0.639	0.641
NUMBER OF COUNTRIES	20	19	19	19	19	19
NUMBER OF OBSERVATIONS	482	269	456	269	269	269

Specification for the regressions used is : $U_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$

[1] Enhanced model includes additional explanatory regressors: active labour market policies expenditure per unemployed and homeownership rates.

[2] This regression analysis includes alternative measure of interest rate volatility IV2.

[3] This regression analysis includes alternative measure of interest rate volatility IV3.

[4] This regression analysis includes alternative measure of interest rate volatility IV4.

[5]F-test on validity of two restrictions in the model of homeownership and active labour market policies indicator both being equal zero.

* result is significant at 10% significance level

** result is significant at 5% significance level

*** result is significant at 1% significance level

Adding two extra regressors to explanatory variables in the regression improved the fit of the model. R squared statistic increased from 0.552 to 0.63. Validity of the further added regressors has been checked by joint F-test on restrictions of additional variables' coefficients equally being zero. Null hypothesis of restrictions joint validity has been rejected by the F-test value 14.000. Inclusion of the extra variables is therefore econometrically justifiable and adds to the model.

According to the enhanced model, coefficient of exchange rate volatility is large in magnitude and highly significant. This is not the only contrasting feature of the variable in the new regression. Direction of inter-relationship between volatility and unemployment has changed. It has been considered negative by models based on earlier specification; here in later model it is positive. Please note that because additional variables have been added due to shortfalls of data availability, observations for Switzerland are not included in the new specification. This reduces our panel size to 19 countries. Additional baseline regression has been run that excludes observations for Switzerland to confirm that results of the enhanced model are not due to country effects. Baseline regression that has been altered to include 19 countries has not shown any signs of improvement. So hypothesis of country effects lying behind the difference in models' estimators has been ruled out.

First interest rate volatility measure that is based on rolling standard deviation suggests that volatility has large and significant result on unemployment formation. It has been decided to confirm if this holds using alternative volatility measures. GARCH based volatility model's estimated coefficients are within a close range of 0.003 to 0.004 and accompanied by high significance of 1%. Lack of previous research creates inability to compare the results for interest rate volatility. However, these results can be compared to previous volatility chapters.

For analogous regressions with exchange rate volatility, standard deviation based measures yielded coefficient within the range of 0.417 to 0.526 and GARCH based measures produced estimates with in the range of 0.140-0.145 percentage points. Similarly, for inflation volatility, standard deviation based coefficient is equal to 0.242 and GARCH based estimates are within the range of 0.023-0.027 percentage points. Looking at GARCH based measures of volatilities - it becomes obvious that interest rate volatility has smallest impact on unemployment out of the three macroeconomic volatilities studied here. What about its impact on overall labour market performance? This question will be answered in the next section, but prior to that only one volatility measure has to be chosen. R squared statistic will be used for this purpose. Regressions based on GARCH volatility measures produce higher R squared statistics despite modest interest rate volatility coefficients. Among them highest R squared value is for the IRV4 based volatility measure so it will be carried forward for further analysis.

6.2.3 Labour market performance: other indicators.

Harmonised unemployment rate is an alternative measure of unemployment rate. It is statistically a better measure for intra-country comparison. It has not been used in baseline or enhanced model specifications due to the relatively small number of observations. However, here it has its chance to be tested. Resulting regression (Table 6-10) coefficient is 0.004 and is accompanied by high significance. This suggests that results are robust and not sensitive to what type of unemployment rate indicator is being used. Direction of the result is supported by employment rate based regression as well. Here, increase in volatility is accompanied by decrease in employment rate. Not only does it decrease the employment rate, but it also affects structural unemployment. One percent increase in interest rate volatility is accompanied by 0.3 percentage points increase in non-accelerating inflation rate of unemployment. This result is very important. Despite its small magnitude, effect on structural unemployment could be accumulative and in long-run could produce considerable disturbances.

Table 6-10 Interest rate volatility effect on labour market performance for OECD countries (1985-2011)

	Harmonised unemployment rate[1]	Employment rate	Activity Rate	Non-accelerating inflation rate of unemployment	Discouraged Workers	Duration of unemployment less than 6 months
Interest rate volatility (IRV4)	0.004***	-0.008***	-0.005***	0.003***	0.003*	-0.021***
Standard error of interest rate volatility coefficient	0.001	0.002	0.002	0.001	0.002	0.005
Output gap	-0.479***	0.187***	0.004	-0.092***	-0.034**	0.645***
Tax wedge	0.026	-0.082**	-0.091***	0.038**	0.015***	-0.721***
Product market regulation	1.087***	-0.044	-0.142	0.356**	-0.209	-0.976
Employment protection policies	-2.505**	2.993***	0.709	-1.637**	1.187***	12.128**
Average benefit replacement rate	0.019	-0.082***	-0.092***	0.033	-0.031***	-0.699***
Union density	0.067	-0.132***	-0.046	0.093***	0.014	-0.733**
Homeownership rate	0.058*	-0.160***	-0.142***	0.034	0.003	-0.481***
Active labour market policies	-1.378***	-0.524	-0.423	0.743	1.553**	6.451*
Time dummies[2]	YES	YES	YES	YES	YES	YES
R^2 within	0.696	0.673	0.529	0.668	0.522	0.621
NUMBER OF COUNTRIES	19	19	19	19	19	19
NUMBER OF OBSERVATIONS	269	198	198	269	135	269

Specification for the regressions used is: $U_{it} = \beta_0 + \beta_1 X_{it} + \alpha_i + d_t + u_{it}$, where explanatory variables include active labour market policies indicator and homeownership rates. Fixed effects estimator is used with Driscoll-Kraay standard errors.

[1]Top row represents labour market performance indicator used as dependant variable for the regression.

[2]Time dummies used are for ussr collapse of 1991, introduction of euro in 2002, and financial crisis of 2008

* result is significant at 10% significance level

** result is significant at 5% significance level

*** result is significant at 1% significance level

But how does it produce disturbance to employment rate? Translated through labour market mechanisms, as can be seen from the other indicators. It decreases activity rates; an increase in volatility of 1% is followed by a decrease in activity rates by 0.3 percentage points. Similarly, further statistics on number of discouraged workers supports the findings. It also prolongs unemployment spells, as it decreases the number of those unemployed for 6 months, by increasing the number of the unemployed for 6-24 months. Despite small coefficient values of volatility, the results are significant in all cases discussed.

6.2.4 Panel time series analysis

The panel time series models path has been chosen from a wide range of dynamic models. This choice was guided by the macroeconomic setting of the research (Eberhardt (2012)).

Analogously to time series analysis we will start with stationarity analysis. Results here are very similar to Chapter 3 unit root tests as models have identical explanatory variables vectors except for distinct volatility measures and two additional regressors. Two tests are available for unbalanced panels – Fischer-type test and Im-Pesaran-Shin (2003) panel unit root test. Second method has been chosen due to asymptotics and data characteristics. For all tests cross-sectional means have been removed so to control for cross-sectional dependence (Levin, Lin and Chu (2002)).

According to test results (Table 6-11), interest rate volatility series are stationary as can be recalled from its estimation and represent variables integrated of order one. What about the rest of the variables? They are all integrated of order one except for output gap indicator that is stationary. In case of homeownership rates and active labour market policies, an adjustment to data has been made. Due to a lack of observations for Switzerland in case of homeownership rates, similarly for Italy in case of active labour market policies, these countries' observations have been removed from the series. This aids us in performing the appropriate unit root tests, otherwise too few observations on one panel blocks us from doing the test. And the problem of observations loss is not that crucial as further modelling in this section is not using these countries' together with three more countries' observations for the same reason.

Table 6-11 Im-Pesaran-Shin (2003) panel unit root tests with crossectional means removed : additional variables for ALMP indicator and homeownership rate included

Variable	Z-t-tilde bar	P-value	Z-t-tilde bar for First Difference of the Variable	P-value for Z-t-tilde bar for First Difference of the Variable	Nature of the variable
Interest Rate Volatility[1]	-	-	-	-	I(1)
Unemployment rate	0.3189	0.6251	-13.8286	0.0000	I(1)
Output Gap	-2.5537	0.0053	-	-	I(0)
Tax wedge	-0.8470	0.1985	-13.0857	0.0000	I(1)
Product market Regulation	2.7576	0.9971	-13.8474	0.0000	I(1)

Employment protection legislation	2.9996	0.9986	-11.5065	0.0000	I(1)
Average benefit replacement rate	1.3056	0.9042	-10.7730	0.0000	I(1)
Homeownership[2]	0.7168	0.7633	-6.7499	0.0000	I(1)
Active labour market policies indicator[3]	-0.1147	0.4543	-8.2843	0.0000	I(1)
Union density	0.0499	0.5199	-14.7132	0.0000	I(1)

H_0: All panels contain unit root

H_1: Some panels are stationary

[1]Interest rate volatility variables are unit root stationary, i.e. integrated of order one as by their construction.

[2]Observations for Switzerland excluded from the sample

[3]Observations for Italy excluded from the sample

Next logical question arising is if the cointegrating relationship exists among the variables. Westerlund (2007) cointegrating tests have been used. All of the four tests are suggestive of cointegrating relationship between unemployment and interest rate volatility. However no cointegrating relationship has been found to include all of the unemployment explanatory variables in the regressions. As no cointegrating relationship exists, Pesaran (2006) common correlated coefficients mean group estimator has been chosen due to its results robustness to no cointegration present, given that all of the variables are integrated of order one.

Table 6-12 Common Correlated Coefficients (CCE) mean group estimators of unemployment determinants for OECD countries (1985-2011)

First differenced variables	Pesaran (2006) Common Correlated Effects Mean Group Estimator	Pesaran (2006) Common Correlated Effects Mean Group Estimator: alternative measure of interest rate volatility IV2	Pesaran (2006) Common Correlated Effects Mean Group Estimator: alternative measure of interest rate volatility IV3	Pesaran (2006) Common Correlated Effects Mean Group Estimator: alternative measure of interest rate volatility IV4
Interest rate volatility (IRV1)	1.936*			
Interest rate volatility (IRV2)		0.248*		
Interest rate volatility (IRV3)			0.249*	
Interest rate volatility (IRV4)				0.303**
Standard error of interest rate volatility	1.039	0.131	0.130	0.139
Tax wedge	0.178	0.090	0.092	-0.044
Product market regulation	-1.408**	-2.817	-2.819	0.219
Employment protection legislation	3.184**	1.144	1.155	0.138
Average benefit replacement rate	0.281	0.501	0.507	0.294
Union density	0.316	-0.299	-0.299	0.138
Homeownership rate	-0.334*	-0.114	-0.110	-0.063

Active labour market policies indicator	-0.659	0.552	0.568	-1.215
Mean of interest rate volatility (IV1)	-1.408			
Mean of interest rate volatility (IV2)		-0.022		
Mean of interest rate volatility (IV3)			-0.022	
Mean of Interest rate volatility (IV4)				-0.013
Standard error of mean interest rate volatility	1.111	0.035	0.035	0.017
Mean of unemployment rate	0.762**	1.010**	1.00**	1.76***
Mean of tax wedge	0.175	-1.120	-1.113	0.268
Mean of product market regulation	0.973	1.118	1.130	0.424
Mean of employment protection legislation	-0.601	4.131*	4.107*	7.649*
Mean of average benefit replacement rate	-0.178	-0.102	-0.106	0.294
Mean of union density	0.929	-0.128	-0.126	0.138
Mean of homeownership rates	-0.189	-0.384	-0.386	-0.063
Mean of active labour market policies	0.627	-0.958	-0.988	-1.215
Number of groups	15	15	15	15
Average number of observations	15.4	15.4	15.4	15.2
RMSE	0..092	0.136	0.136	0.133

* Result is significant at 10% significance level, ** result is significant at 5% s.l., *** result is significant at 1% s.l.

So model includes all the variables discussed in first differenced form except for output gap due to its stationarity. Dynamic model results are presented in Table 6-12 with alternative volatility measures. Omission of output gap variable is of no concern as Pesaran (2006) model corrects for that as well (Eberhardt (2012)). For all volatility measures, interest rate volatility in short run has positive contributing impact on change in unemployment. As before, coefficients obtained from GARCH based measures are smaller in magnitude than the one obtained from rolling standard deviation. All of the interest rate volatility coefficients are significant at least at 10% significance level, with IV4 measure yielding higher significance level of 5%. However, according to root mean square analysis volatility measure constructed as rolling standard deviation is the best performer across dynamic models discussed. Regression with this volatility measure has smallest root mean square error of 0.092. So for further research concerning short-run dynamics IV1 measure will be used.

Further our interest is concerned with the problem of causality. Is it fluctuations in volatility causing fluctuations in unemployment or fluctuations in unemployment causing volatilities to adjust? Granger Causality tests will be performed based on methodology of IMF (2014, pp.107-108) and Bassanini and Duval (2009).

Table 6-13 Granger Causality tests for interest rate volatility and unemployment rate[1]

	Dependent Variable is unemployment rate.	Dependent Variable is interest rate volatility
Unemployment rate first lag	0.547***	0.054*
Unemployment rate second lag	-0.145***	-0.001
Interest rate volatility first lag	-0.056	0.644***
Interest rate volatility second lag	0.123***	0.015
Joint F-test	5.18	1.80
Prob > F	0.058	0.1661
Number of observations	791	771

* Result is significant at 10% significance level, ** result is significant at 5% s.l., *** result is significant at 1% s.l.

[1]All variables here, dependent and explanatory are in first differences.

Previously I (1) nature of unemployment and interest rate volatility variables has been confirmed by the variable construction methodology and appropriate Im-Pesaran-Shin (2005) unit root tests. Then Westerlund (2007) tests have suggested cointegrating relationship between the variables. So to do Granger causality tests fixed effects regressions with lags order up to two have been run inclusive of time dummy variables. F-tests for the validity of the lagged variables have been performed. In first regression, where unemployment rate is a dependent variable, second lag of interest rate volatility is highly significant at 1% significance level. And it increases unemployment rate with the effect relatively smaller in magnitude comparing to previous regressions. Joint F-test, with the value of 5.18, rejects the null hypothesis to suggest that coefficients of lagged interest rate volatility are different from zero. In second regression, where interest rate volatility is a dependent variable, first lag of unemployment rate is significant at 10% significance level and is small in magnitude. Joint F-tests on lagged unemployment rate variables suggest that variables coefficients are not different from zero. Suggesting there is no inverse Granger causality between unemployment rate and interest rate volatility. So interest rate volatility Granger causes unemployment rate but not vice versa.

6.2.5 Conclusion.

Significant coefficients of interest rate volatility have not been found in any variations of fixed or random effects regressions explaining the unemployment rate. Additional variables have been included to baseline specification to achieve a better labour market model.

Here, fixed effects estimator with Driscoll-Kraay standard errors has been evident of highly significant relationship between interest rate volatility and unemployment rates. This result has been supported by all alternative volatility measures. Looking at a wider picture of labour market performance, it has been found that interest rate volatility is positively associated with structural unemployment and number of discouraged workers, but negatively associated with employment and activity rates. It is also negatively correlated with the duration of unemployment, as it is positively associated with the indicator of unemployment duration of more than 6 months.

Robustness checks performed using Pesaran (2006) common correlated mean group estimator support the validity of the established results. Furthermore, Granger causality tests support the hypothesis that interest rate volatility Granger causes an increase in unemployment rate. Additionally, there was no inverse causality found. Still, I would like to bring the readers attention to the fact, that due to the methodology limitation, Granger causality is not sufficient to declare any general causal relationship between interest rate volatility and unemployment rate. Here, the findings should be regarded as having a correlations nature, rather than a causal impact.

Chapter 7. Concluding remarks

7.1 Summary of results

Results of the study suggest that there is macroeconomic volatility unemployment link. First of all it has been found that macroeconomic volatility has adverse effect on labour market performance. It has been supported using a number of labour market performance variables such as: activity rates, employment rate, unemployment rate, structural unemployment, discouraged workers, and duration of unemployment.

Effect of macroeconomic volatilities on labour market performance is relatively small in magnitude but in most regressions is significant. Relatively to other macroeconomic volatilities, interest rate volatility has larger impact on labour market performance whereas inflation rate volatilities have the smallest. According to regressions based on fixed effects with Driscoll-Kraay standard errors, one standard deviation increase in exchange rate volatility is associated with 0.29 to 0.37 percentage points increase in unemployment rate dependant on the measure chosen. Similarly, if taking into the view enhanced labour market model inclusive of ALMP and homeownership indicators, then one percentage point increase in interest rate volatility is accompanied by 0.21 to 0.52 percentage points increase in unemployment rate dependant on volatility measure chosen. In case of inflation rate results, LSDVC regressions are used for the benchmark comparison. One standard deviation increase in inflation volatility is associated with 0.09 to 0.12 percentage points increase in unemployment rate. Evidence for the results is strongest for exchange rate volatility (higher significance in larger number of regressions) and relatively weaker significance for interest rate volatility.

Despite the effect being small in magnitude, the economists should not ignore it instead they should be encouraged to take the research further. At this stage research does not present any suggestions to policymakers. This is because there is not enough done at the field yet to make any valuable conclusions. Before this area of research could become of any interest to policymakers, macroeconomic volatility effect has to be studied in conjunction with the other policies' interactions, and only then could any practical implications be drawn.

This study extends the research field in a number of ways. Firstly, it brings in new and more advanced volatility measures. Secondly, it includes a number of labour market performance measures, rather than simply unemployment rate. Thirdly, it incorporates new macroeconomic volatility measure in the research that has not been studied before – the interest rate volatility.

For the ease of comparison to previous studies popular volatility measures have been additionally included. They are rolling standard deviation technique and GARCH(1,1) models of volatility. Overall, where possible, research results have been compared to previous studies – it has been concluded that results of this study are in line with the previous research outcomes.

7.2 Research limitations

7.2.1 Endogeneity

Estimation in all of the chapters has been started with the simple panel techniques – fixed effects or random effects models. Estimators have been checked and corrected for all possible inefficiencies that arise in presence of autocorrelation, heteroskedasticity or cross-sectional dependence. However, these techniques rely on the assumption of strict exogeneity by definition, i.e. zero autocorrelation between explanatory variable and the idiosyncratic error term (Wooldridge (2013)).

Endogeneity may arise from a number of sources such as unobserved simultaneity bias, heterogeneity and measurement error. One of the ways to deal with the endogeneity problem is to use Instrumental Variables (IV) based approach. However, this approach doesn't suit this research for a number of reasons. Firstly, IV techniques have drawn much criticism because of their fundamental assumptions. At the heart of the method lies the idea of finding a suitable alternative variable (instrument) to the control variable that is being tested for the substitute. This instrument variable should be highly correlated with the initial variable, but uncorrelated with the idiosyncratic term. First assumption can be easily tested, however the following addition of collinearity with the error term is impossible to test. This is not the only pitfall of the analysis. Roodman (2009) also criticises the technique for the problem of "instrument proliferation" that it creates. Coming back to the questions that lie at the heart of this research, IV approach is not suitable, as it has been designed with a large number of panels in mind, as well as a short span of time series observations. For a macroeconomic dataset as here it will be highly unsuitable. So what other options arise under current circumstances?

Eberhardt (2012) proposes the use of panel time-series models in such circumstances. Pesaran(2006) addresses some of the issues and comes up with the new common correlated effects mean group estimator. Estimator is robust to endogeneity induced by variable omission, and “local spill over effects” (Eberhardt (2012)). However, this alternative method could not be applied to all of volatility effect chapters. Inflation volatility measure is fractionally integrated. No answer has been found on the question of how to treat fractionally integrated variables in the panel time-series. Same order of integration lies at the basis of its assumptions.

For inflation volatility series regressions microeconomic panel techniques has been used. Arrelano-Bond (1991) estimator has been chosen in line with Sargan tests, as well as the first and second order autocorrelation tests results. Still the model is not describing microeconomics data, and so for the robustness of the results, Bruno (2005) methodology has been used. He proposes using Least Square Dummy Variables approach with standard errors corrected by one of the dynamic models. As Sargan test for over identifying restrictions and Arrelano-Bond first and second order of autocorrelation tests suggest, Arrelano-Bond (1991) estimator has been chosen for the correction. This estimator has been designed to work for the models with smaller panels, but larger time-series dimension of data. That is suitable for the model.

7.2.2 Causality

Questions of causality have been attempted in this research. Where possible, in particular in Chapters 4 and 6, Granger Causality tests have been performed using technique described in IMF (2014, pp.107-108) and Bassanini and Duval (2009). However, in Chapter 5 because of variable of interest stationarity nature (fractionally integrated variable) Granger Causality techniques appeared to be of no practical use. Therefore, Granger causal relationship between inflation volatility and unemployment has not been determined. Granger causality is not a sufficient condition for being able to declare a causal impact between the variables however. And so, due to the methodology limitations, no relationships in this research should be thought of as a causal impact, but should rather be regarded as correlations between the variables of interest.

7.2.3 Collinearity of the macroeconomic volatility variables

Macroeconomic volatility variables could be perfect substitutes for each other. In this case, it is the general macroeconomic volatility effect in all of three chapters that could have been studied, rather than the distinct volatility variables. In finding answers to the problem, collinearity matrix of the variables has to be considered (Appendix A6). There is collinearity of volatility measures within the variables, but there is no cross-collinearity has been found among volatility measures of different variables. So based on that it can be concluded that volatility of exchange rate, inflation and interest rate are not correlated and consequently do not suffer from the associated problems described earlier.

7.3 Further research suggestions

Limitations of the study give rise to further research suggestions. In particular, developing or using alternative techniques to tackle further endogeneity and tests of causality between the variables would be good improvements. One of the ways to reduce the limitations of the research is to expand the dataset in panel dimension. So far, studies have been concerned with either 20 industrial countries (Feldmann (2012)), Asian Countries (Shen (2011)) or solely Turkey (Demir (2009)). Creating cumulative dataset inclusive of industrial countries, Asian, Latin American, African and CIS economies would create a panel data with large N dimension and relatively small T (30 observations) dimension. Then Instrumental Variables approach can be used for estimation with the corrections described by Roodman (2009).

During the work on the thesis, a number of questions and possibilities had arisen that unfortunately have not been in the scope of this study for different reasons. This research has more potential and further research suggestions are listed below. All of the suggestions are concerned with dataset construction.

Not all of the variables of interest have been included in the dataset. An attempt has been made to include macroeconomic shock variable into the dataset, but due to data availability and changes in data definitions, they have been left behind.

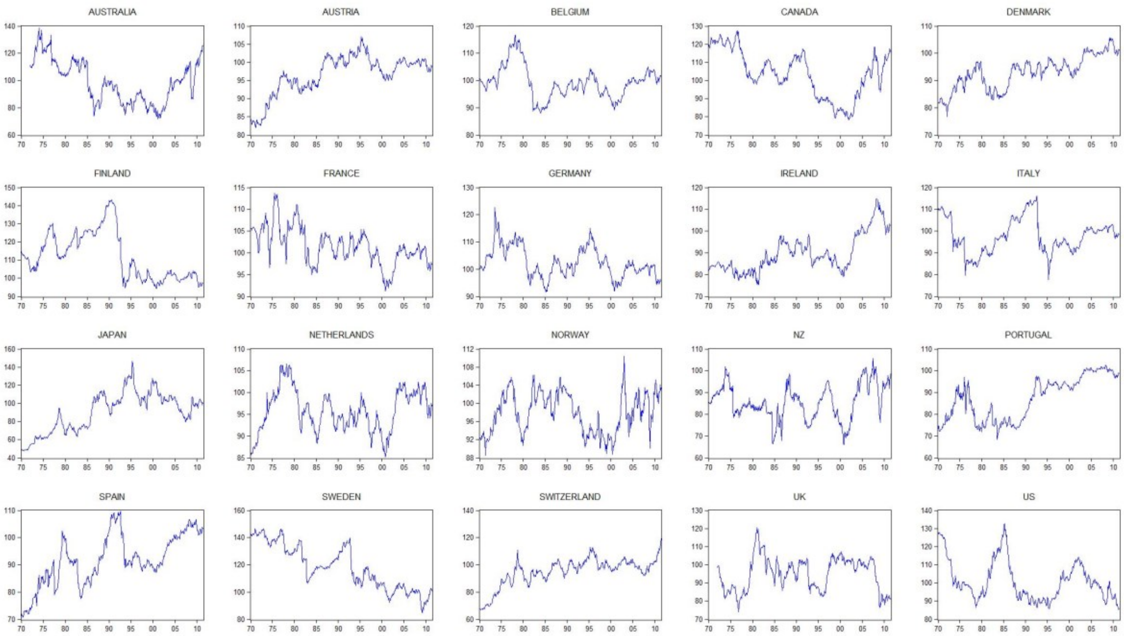
Furthermore, this study has been concerned with labour market performance and a number of performance indicators have been looked at. However, regretfully due to time limitations and no readily available data, impact of volatilities on the labour market flows has not been considered. This could have been a good addition however. Advantages and practical aspects of the labour market flows indicators are extensively described in Davis et. al. (2006), Gomes (2012), Nissim (2009) and OECD (2010c).

There is room for improvement in volatility measures approach as well. In particular when fitting volatility to the interest rate models, a good alternative to consider would be regime-switching models. This approach to measuring volatility of interest rates has been overlooked by a number of previous studies, for example Gray (1996). This alternative measure appeared to be a good performer. This does not come as a surprise, because central banks use interest rate as a tool to track inflation during adverse economic conditions.

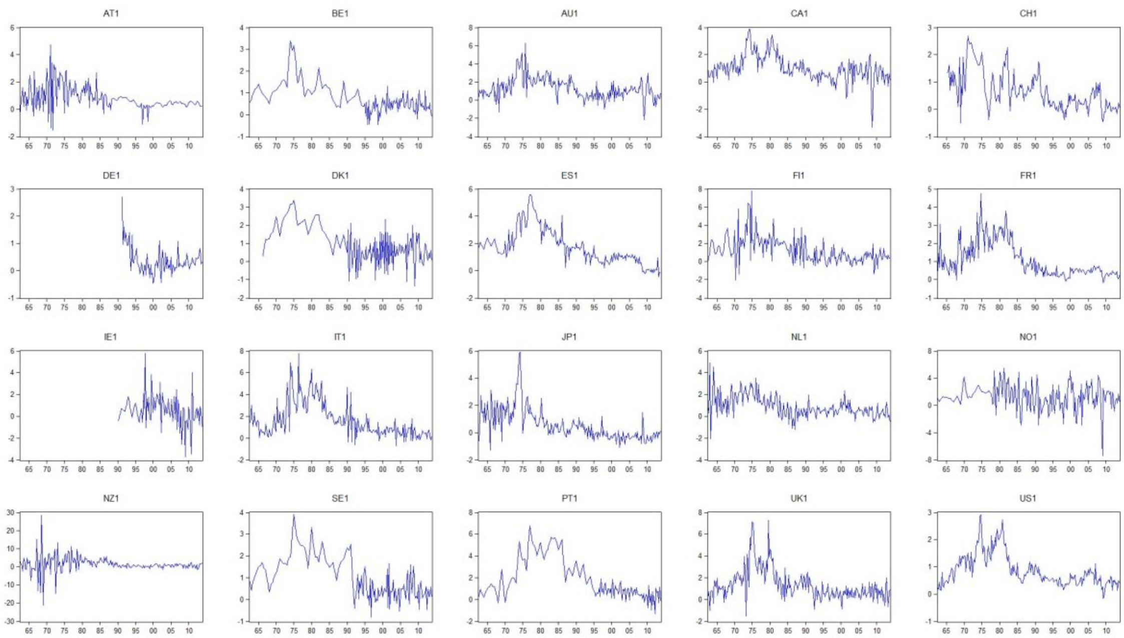
Volatility effect on labour market performance has been considered to a great extent in this study in a number of specifications, and using a number of estimators. Unfortunately, volatility measures intersections with policy and institutional indicators' effects on labour market performance have not been considered.

Appendix A1: Plots of macroeconomic variables

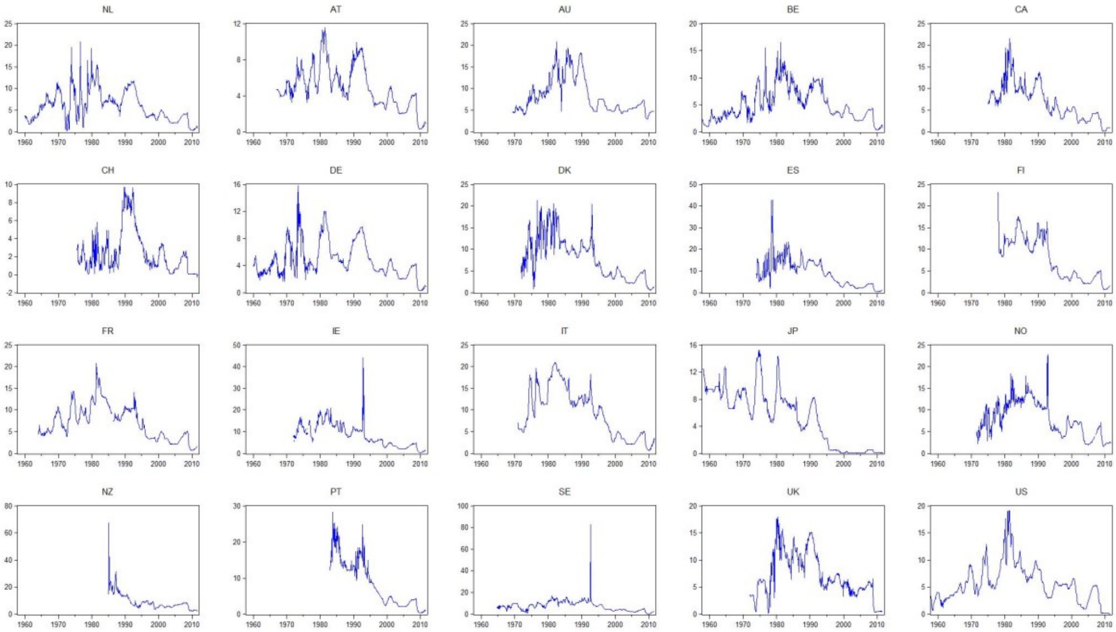
1. Exchange rate series.



2. Inflation series.

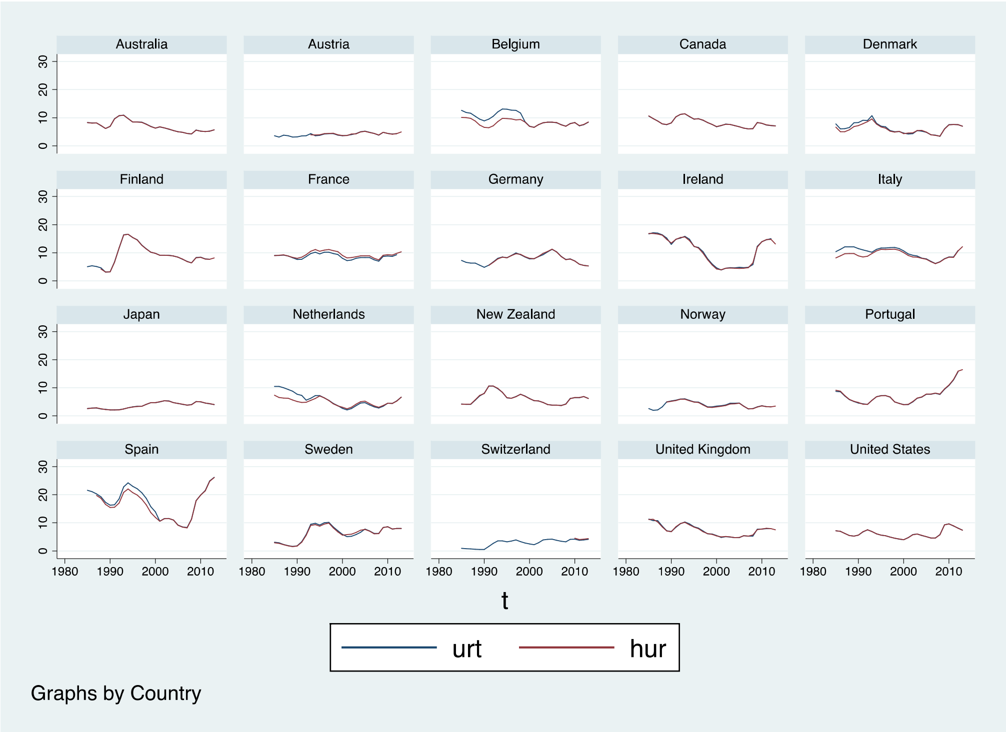


3. Interest rate series.



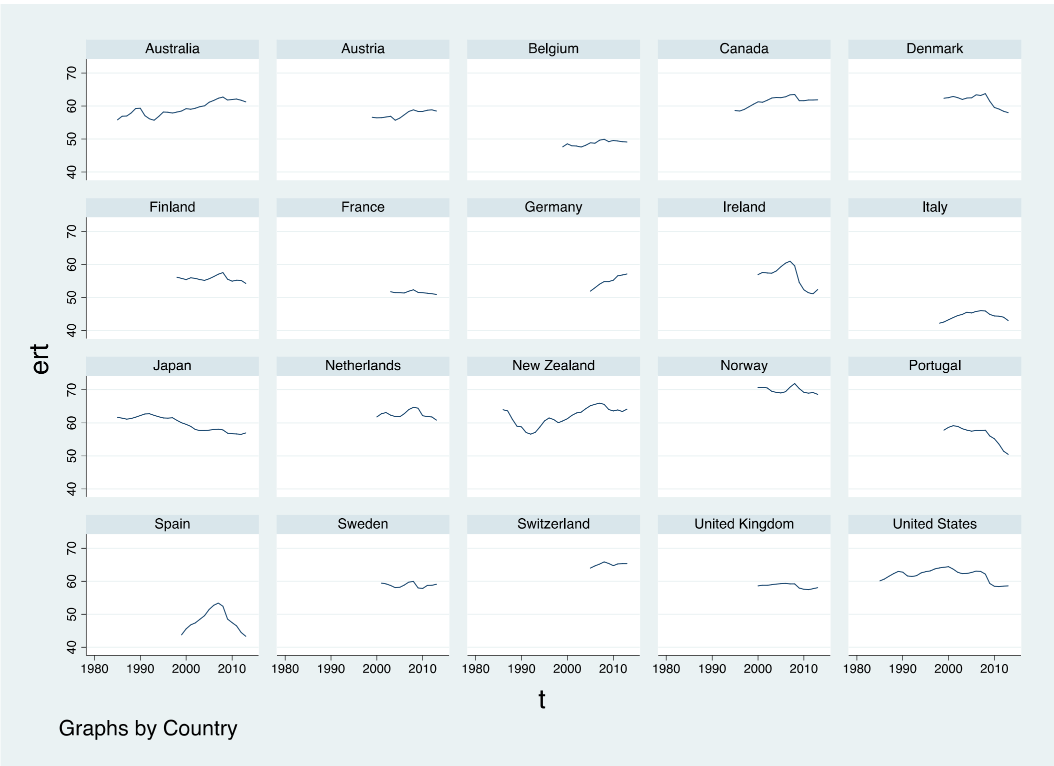
Appendix A2: Plots of key labour market performance variables

1. Comparative graph of "unemployment rate" derived from two sources.

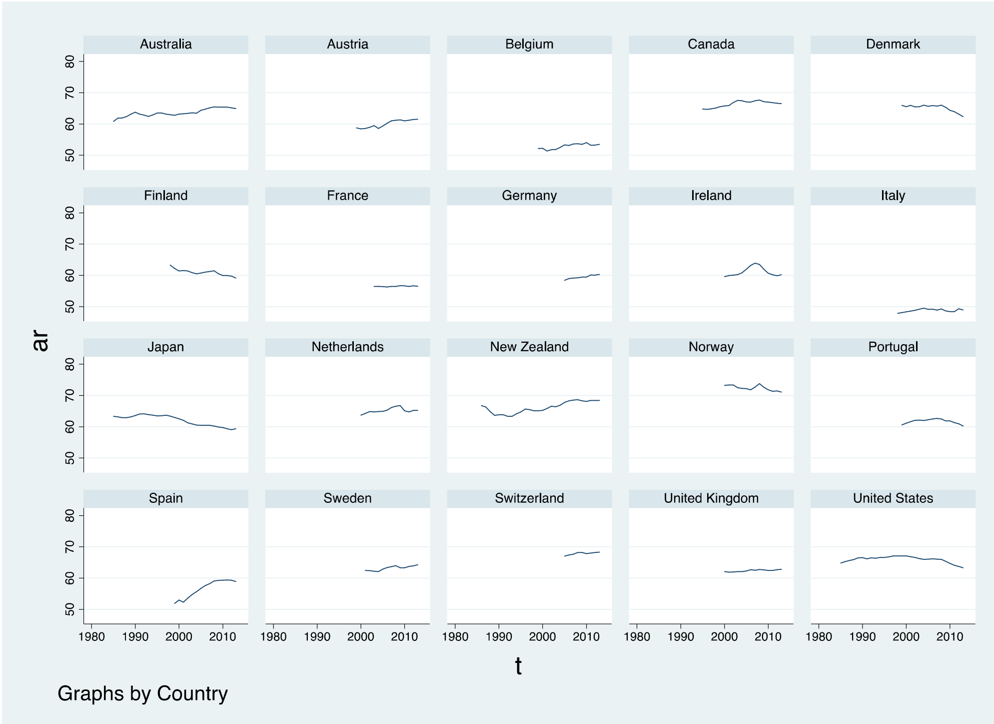


urt – Unemployment Rate (ALFS definition)
hur – Harmonised unemployment rate
t- time, Year

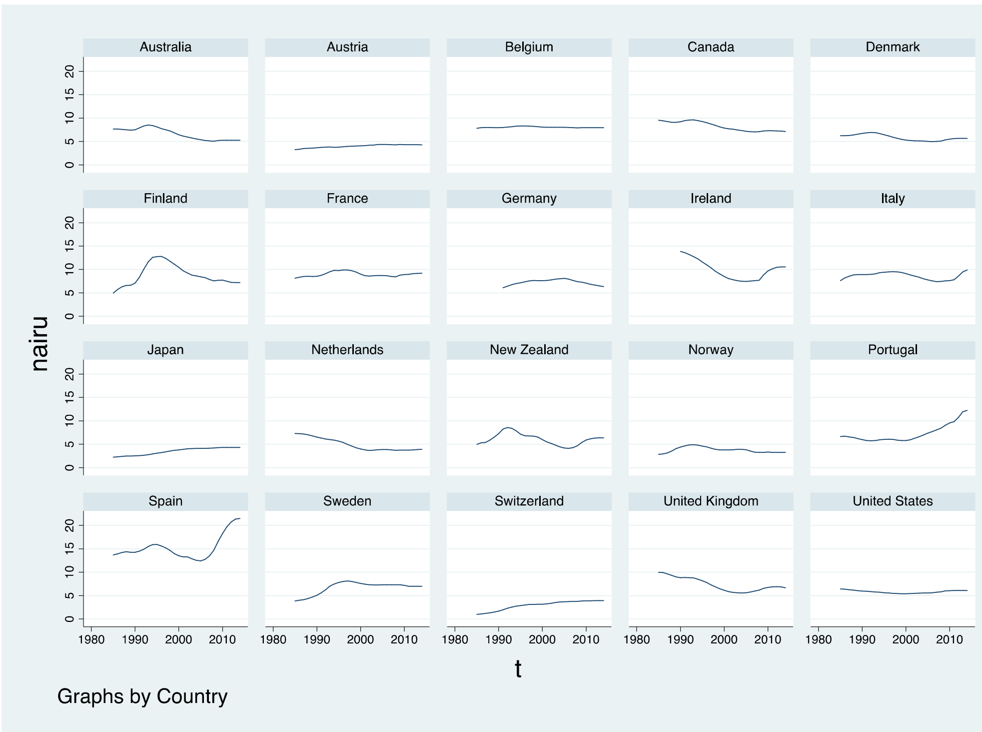
2. Graph of "employment rate" variable.



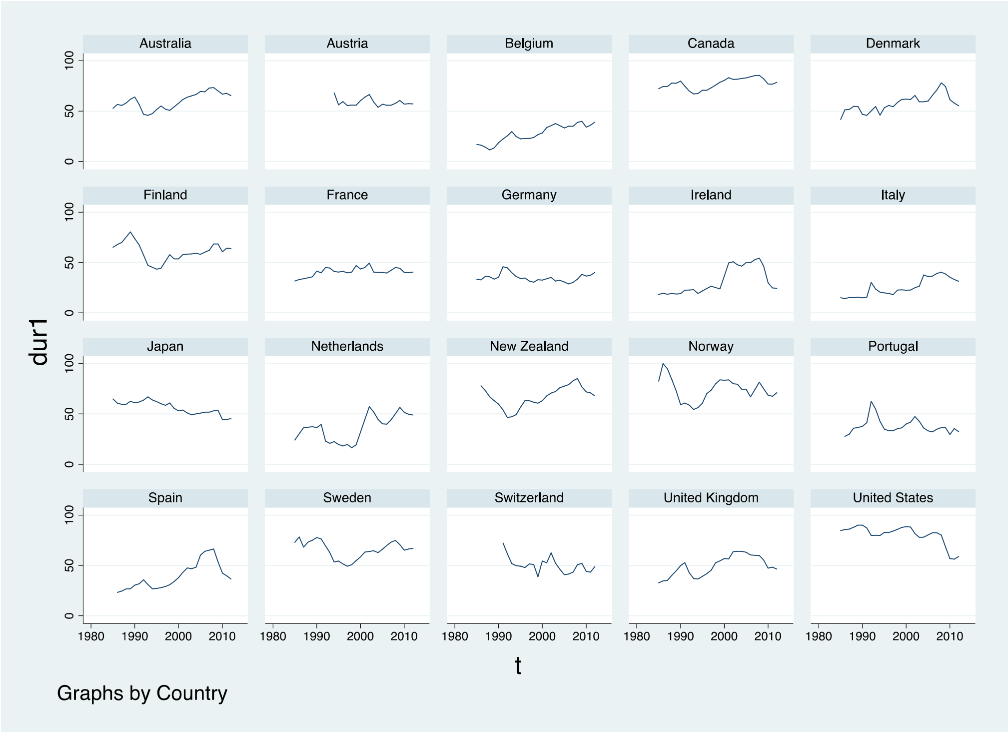
3. Graph of “activity rates” variable.



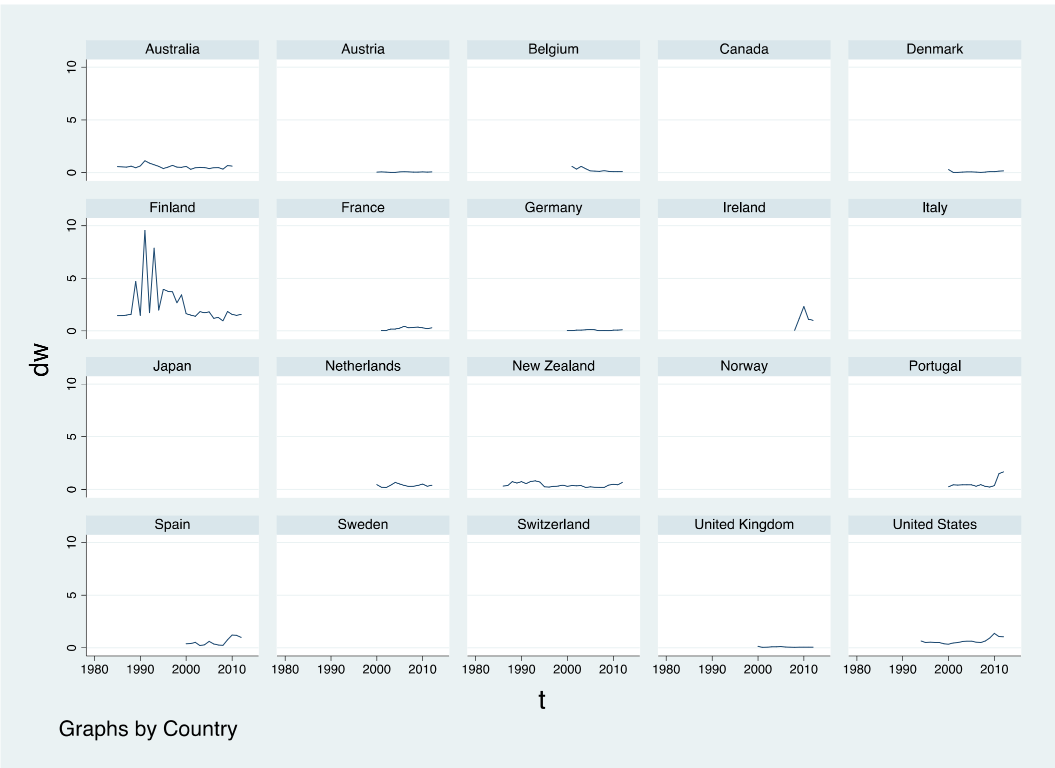
4. Graph of “Non-accelerating inflation rate of unemployment” variable.



5. Graph of “duration of unemployment” variable.

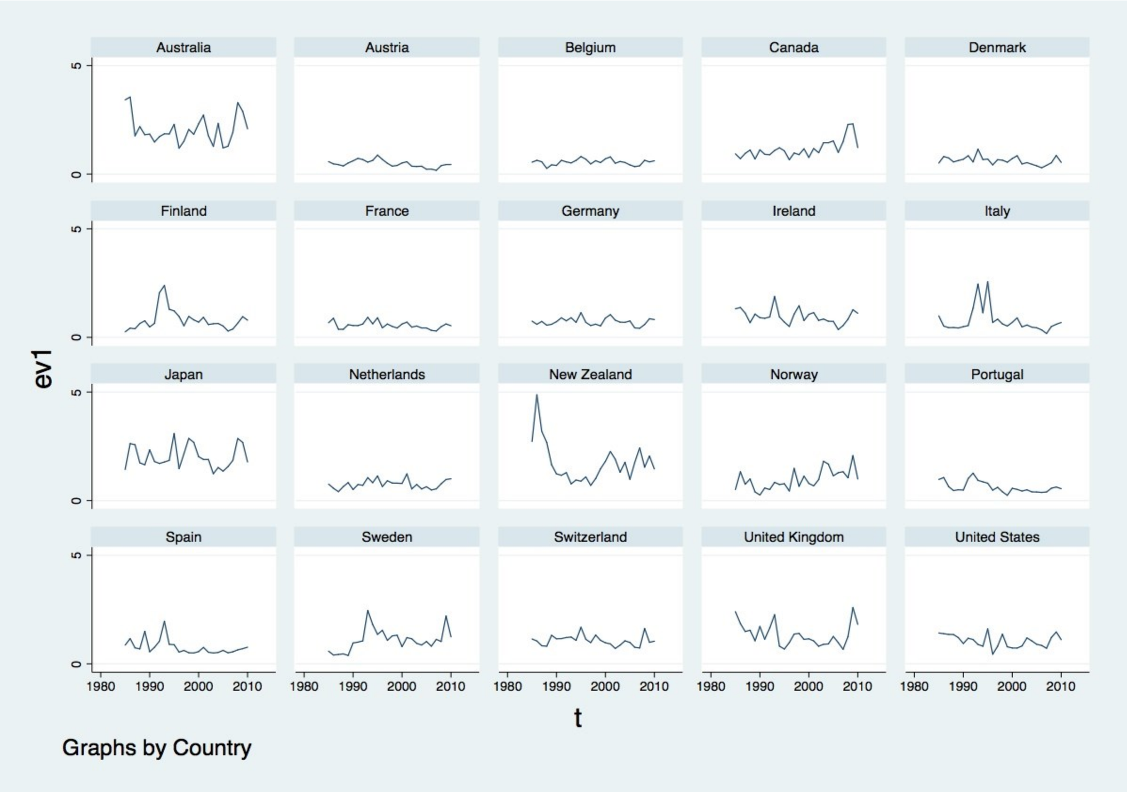


6. Graph of “number of discouraged workers” variable.

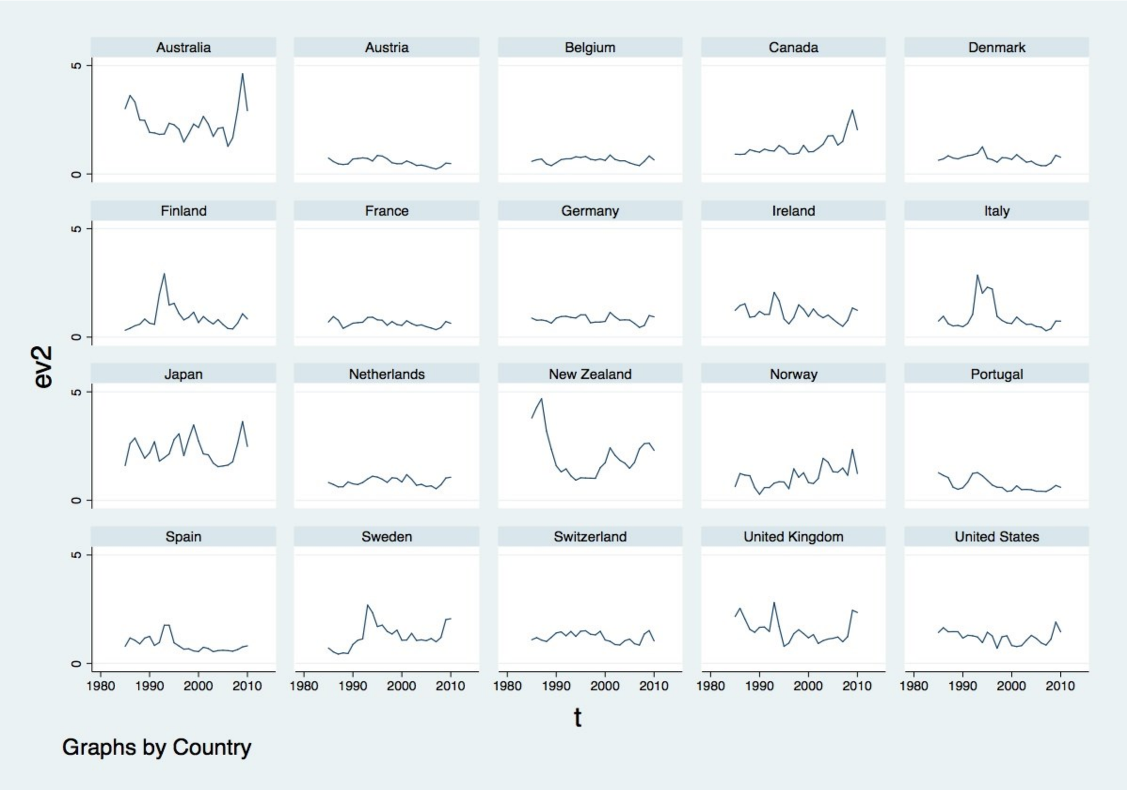


Appendix A3: Plots of exchange rate volatilities

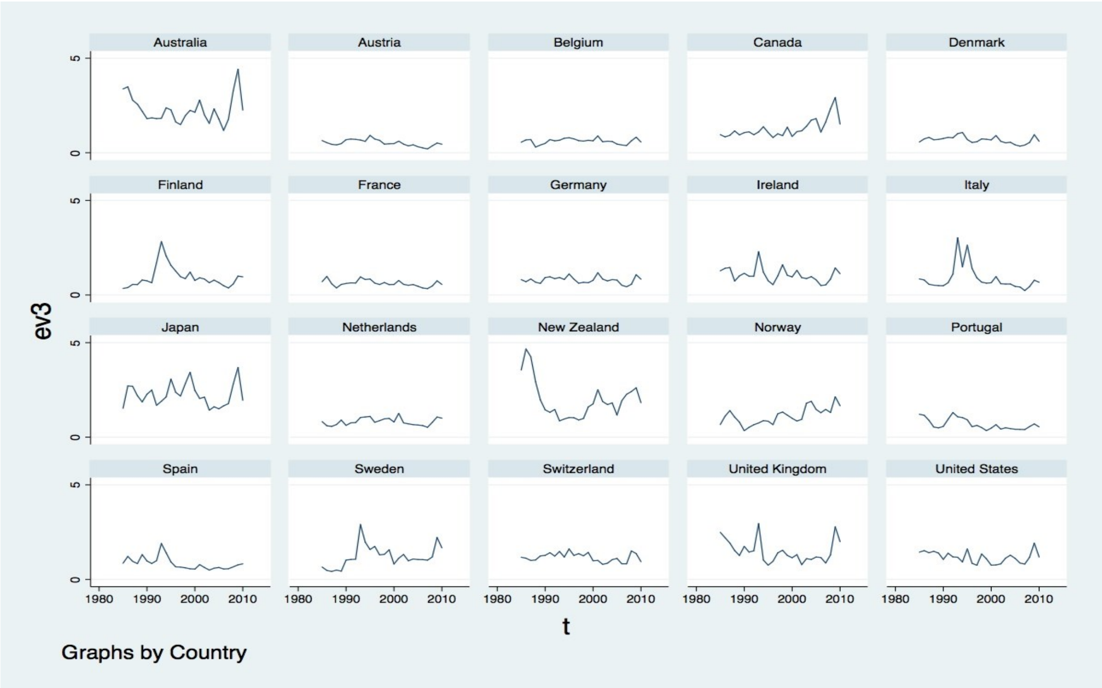
1. EV1: Measure based on rolling standard deviation of 6 months lag length



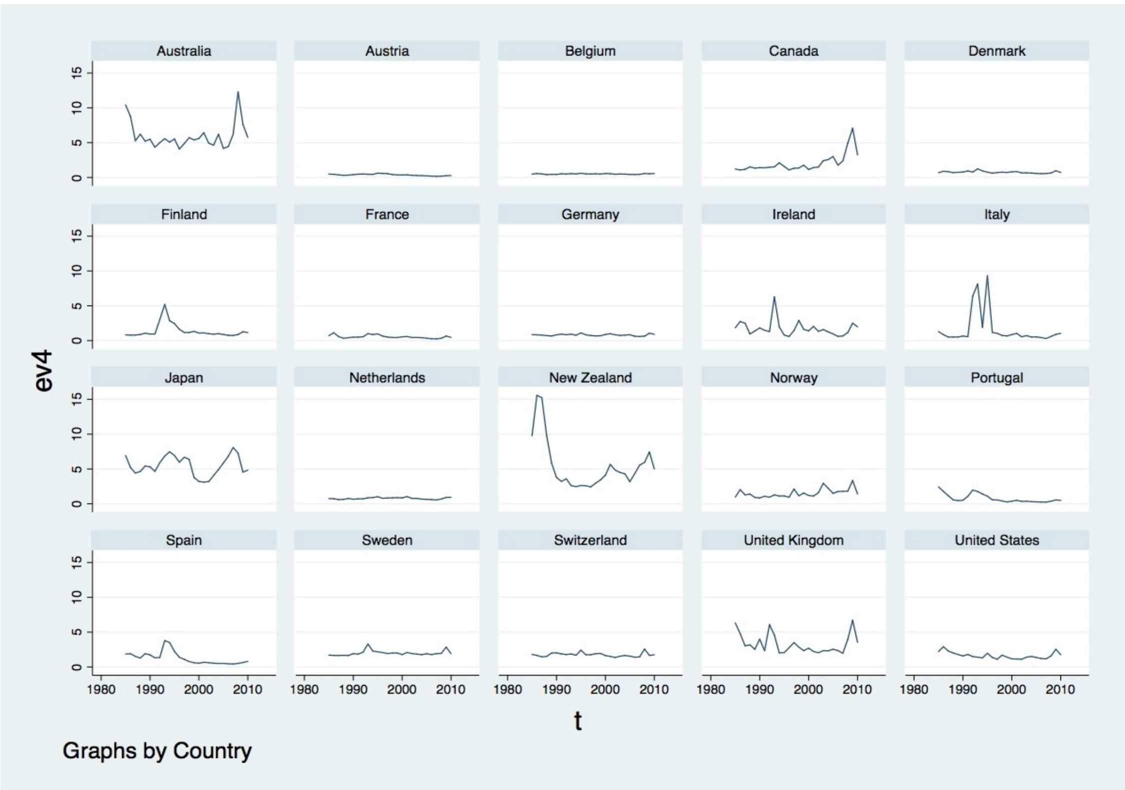
2. EV2: Measure based on rolling standard deviation of 12 months lag length



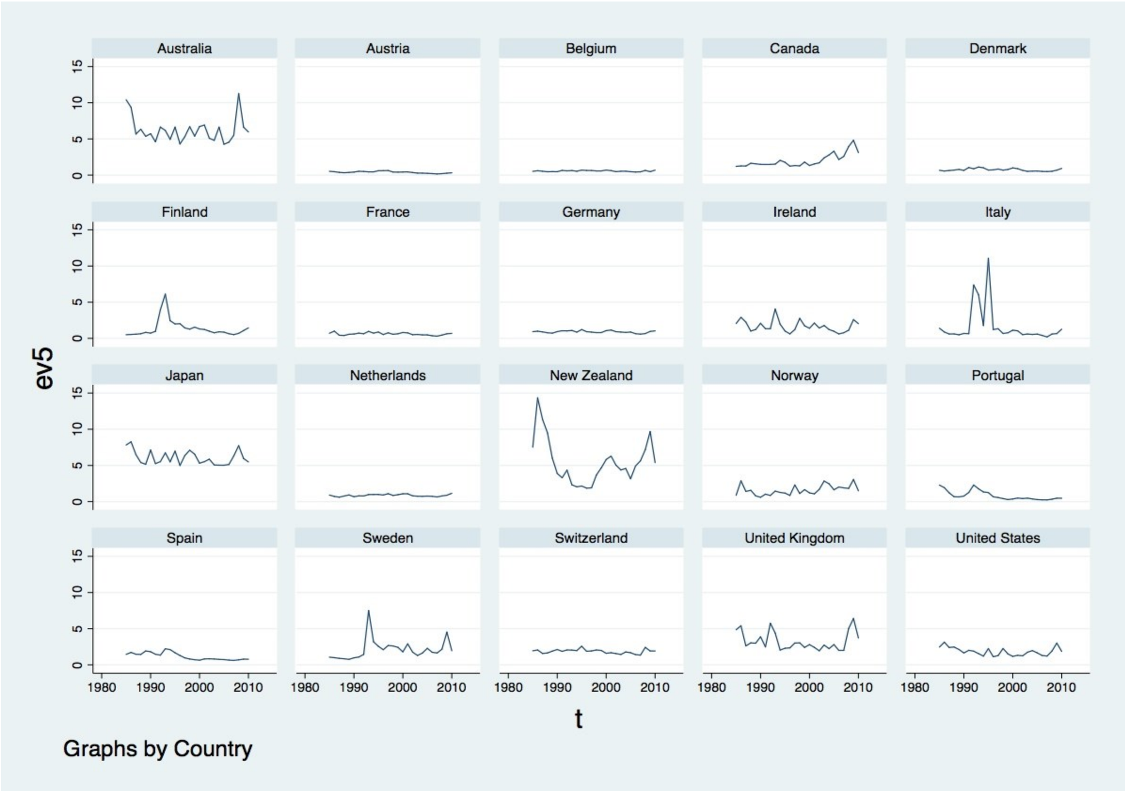
3. EV3: Measure based on rolling standard deviation of 18 months lag length



4. EV4: Measure based on ARIMA-GARCH modelling.

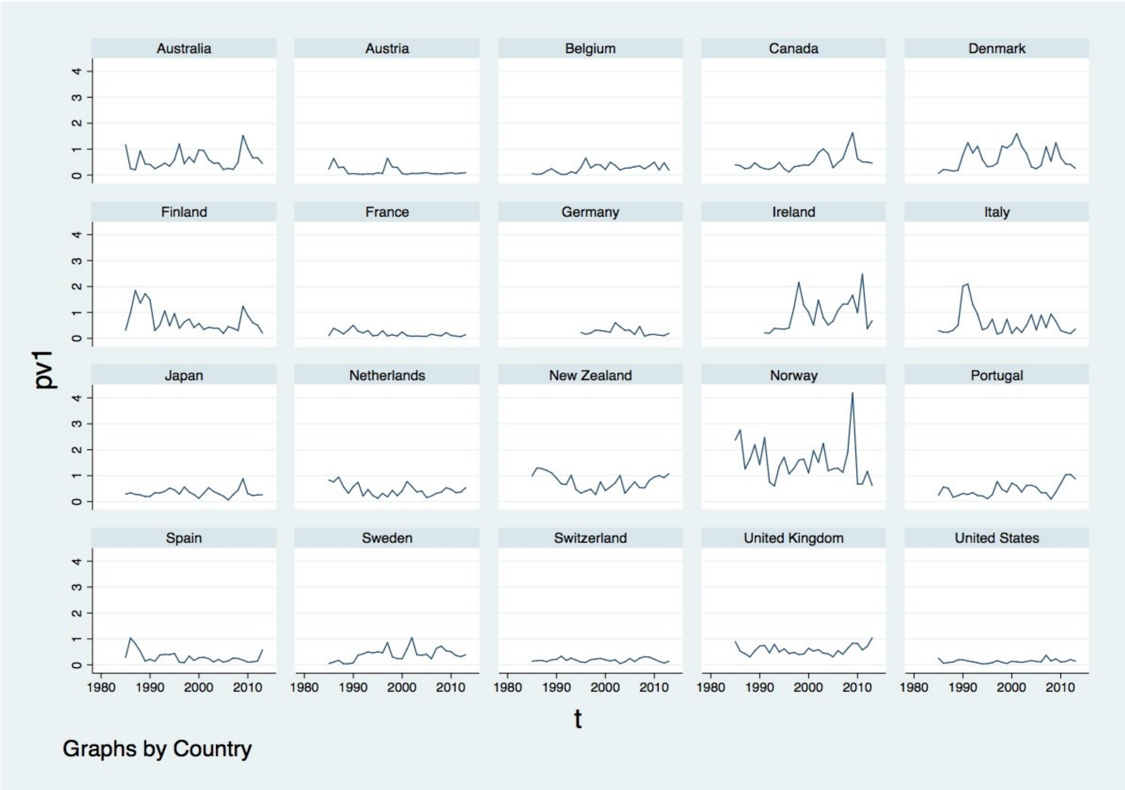


5. EV5: Measure based on ARIMA-EGARCH modelling.

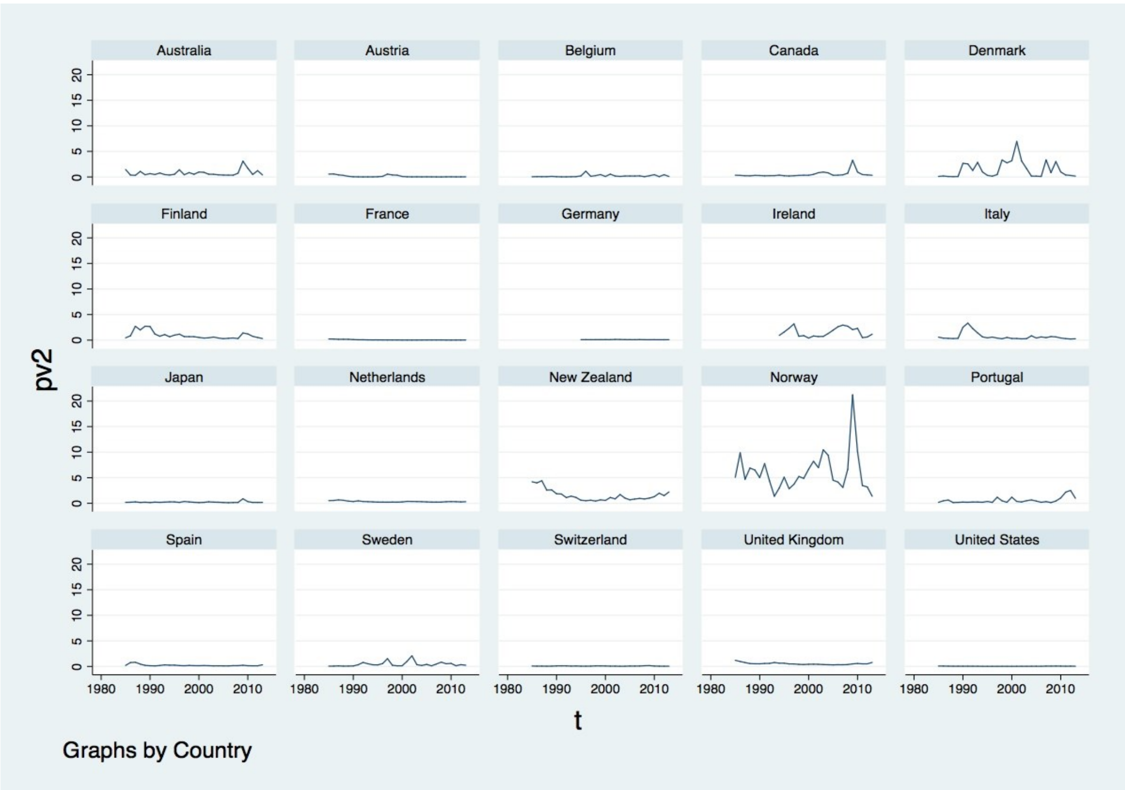


Appendix A4: Plots of inflation rate volatilities

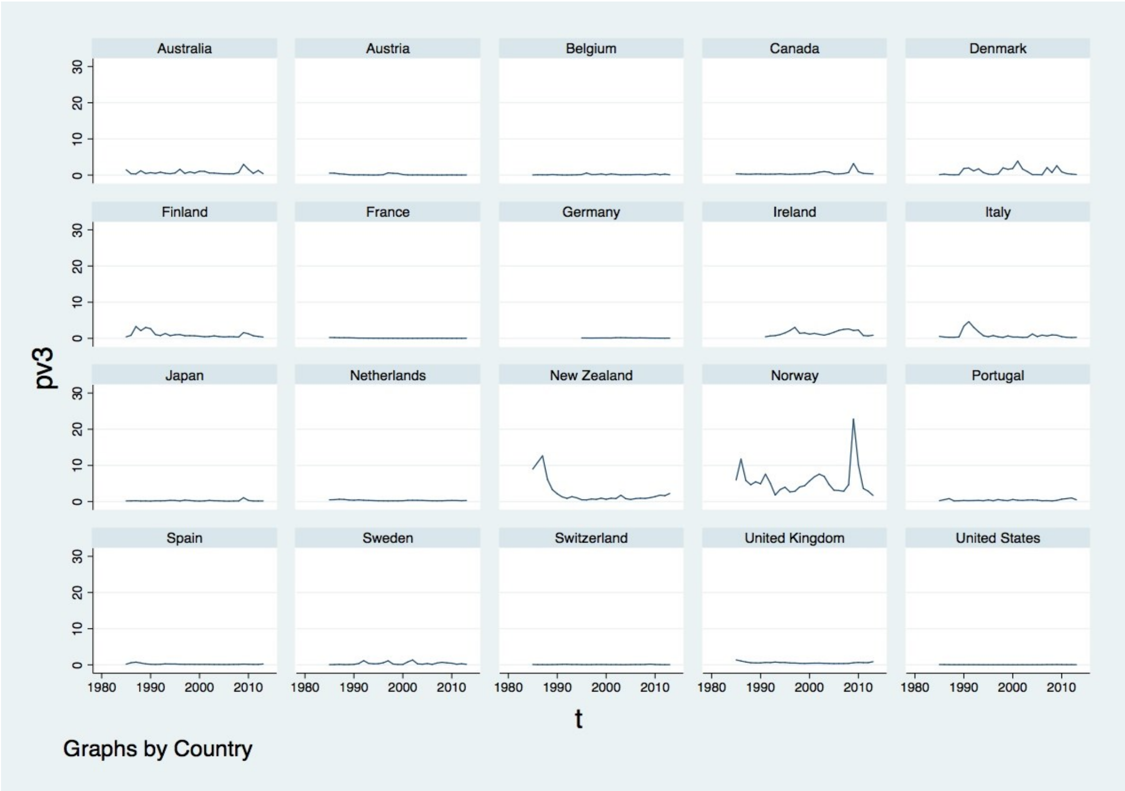
1. **PV1: Measure based on rolling standard deviation of lag lengths 4**



2. **PV2: Measure based on ARFIMA(0,d,0) – GARCH(1,1)**

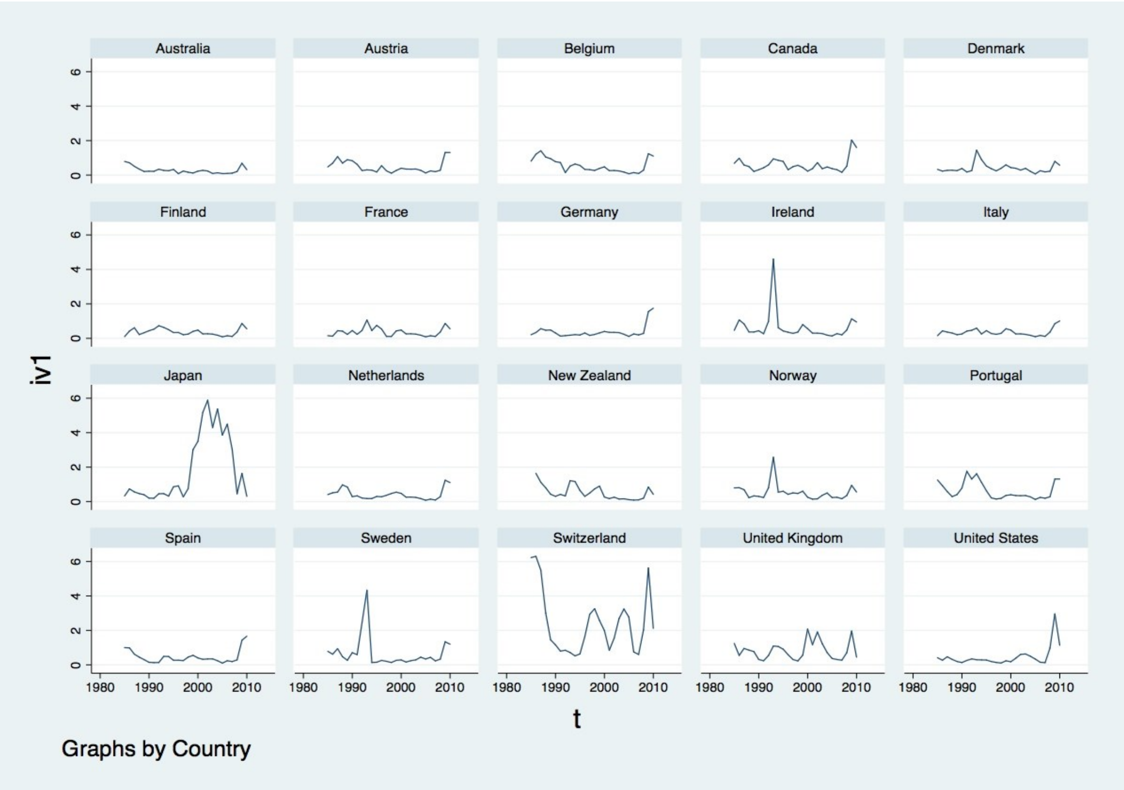


3. PV3: Measure based on ARFIMA(0,d,1) – GARCH(1,1)

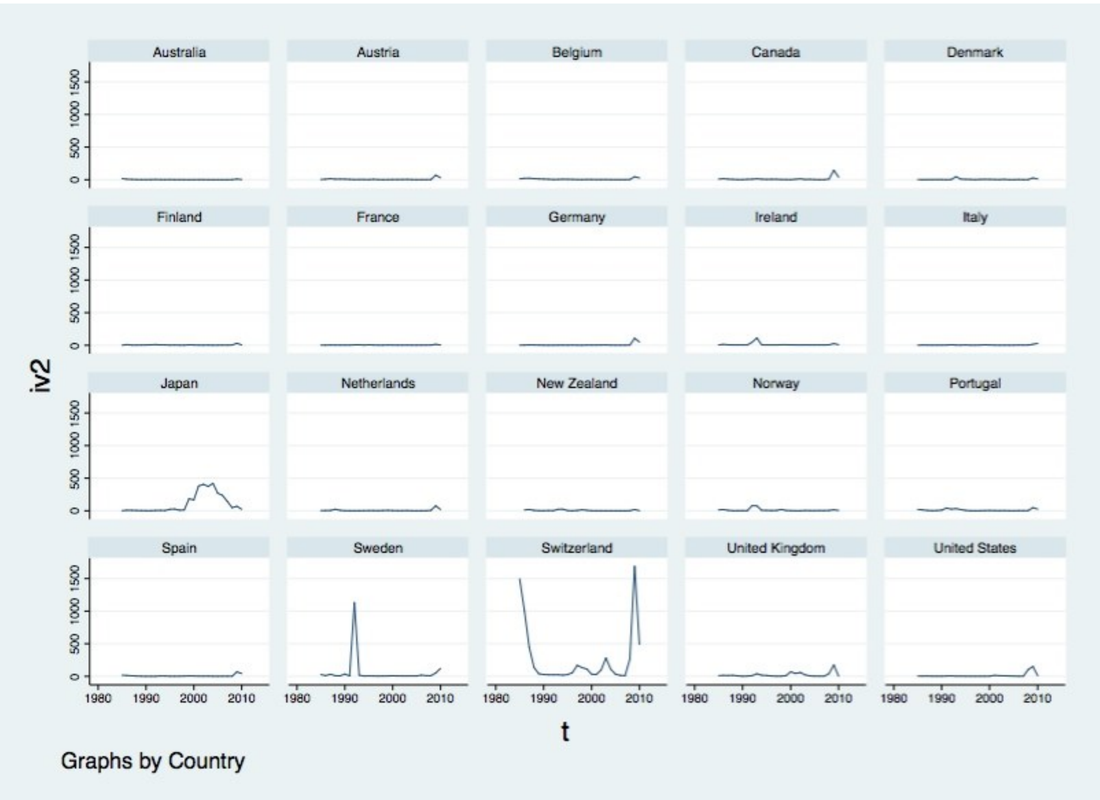


Appendix A5: Plots of interest rate volatilities

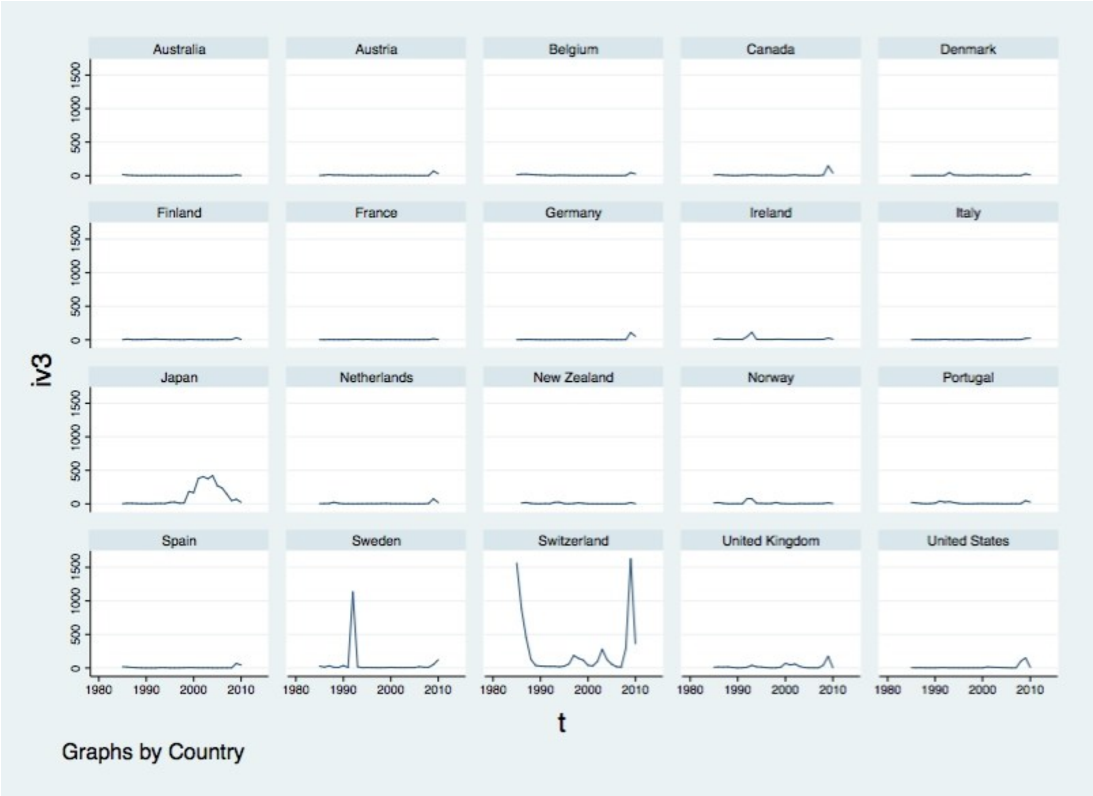
1. **IRV1: Measure based on rolling standard deviation of lag lengths 12**



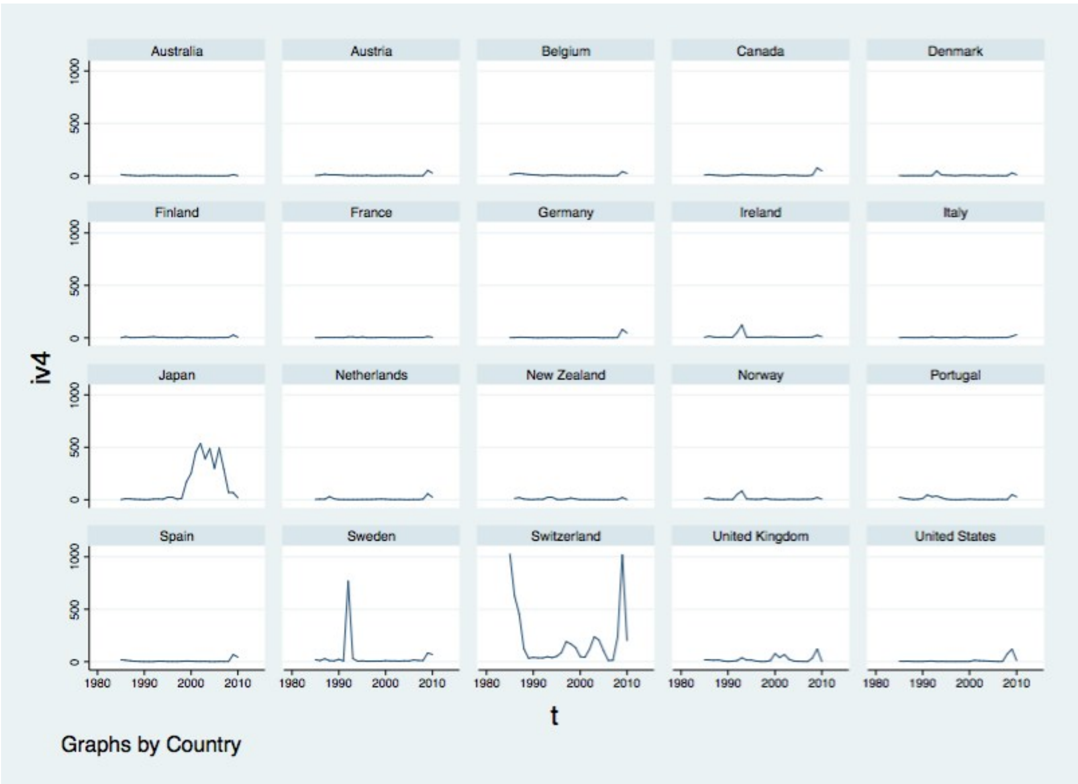
2. **IRV2: Measure based on either GARCH(1,1) or GJR-GARCH(1,1)**



3. IRV3: Measure based on QGARCH(1,1)



4. IRV4: Measure based on either GARCH(1,1) or PARCH(1,1)



Appendix A6: Collinearity of macroeconomic volatility measures

Diagram 3 Collinearity matrix of macroeconomic volatility measures

	EV1	EV2	EV3	EV4	EV5	PV1	PV2	PV3	IRV1	IRV2	IRV3	IRV4
EV1	1.00											
EV2	0.89	1.00										
EV3	0.95	0.97	1.00									
EV4	0.87	0.85	0.87	1.00								
EV5	0.90	0.86	0.89	0.94	1.00							
PV1	0.17	0.17	0.18	0.17	0.15	1.00						
PV2	0.11	0.11	0.13	0.09	0.07	0.82	1.00					
PV3	0.18	0.19	0.20	0.19	0.16	0.80	0.94	1.00				
IRV1	0.14	0.16	0.15	0.10	0.08	-0.06	-0.05	-0.03	1.00			
IRV2	0.06	0.08	0.07	0.03	0.02	-0.07	-0.05	-0.05	0.81	1.00		
IRV3	0.06	0.08	0.07	0.03	0.02	-0.07	-0.05	-0.05	0.81	1.00	1.00	
IRV4	0.07	0.09	0.08	0.05	0.04	-0.06	-0.06	-0.05	0.87	0.97	0.97	1.00

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